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BULLETIN No. 234

A GRAPHICAL PRESENTATION OF THE FINANCIAL PHASES OF FEEDING EXPERIMENTS

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A GRAPHICAL PRESENTATION OF THE FINANCIAL PHASES OF FEEDING EXPERIMENTS

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INTRODUCTION

In the ordinary type of feeding experiment there are essentially three experimental results; namely, the rate of gain of the animals, the economy of gain expressed in terms of the ration tested, and the market finish produced. The first two items can be measured accurately in any particular feeding operation, tho they are subject to a variable and oftentimes considerable experimental error when considered as experimental data. The third item is not susceptible of exact measurement and can be described only by stating the grade of butcher stock as judged by competent buyers, or its selling price per hundredweight relative to the prevailing market prices.

All statements made of the monetary cost of gains and of the profits returned from any experimental feeding operation are necessarily not experimental results, since they depend so largely upon factors not under experimental control and not subject to any predictable variation, i. e., the prevailing market prices of feeds and live stock. The economy of any system of feeding, expressed in terms of commodities, has a permanent value; whereas when expressed in terms of financial profits or losses for any given set of prices, it will have little if any value. The latter expression is, and should be, of interest only to the experiment station conducting the work, and then only as an item in its ledger accounts.

In spite of these facts, it is in general only the financial phases of experimental feeding operations that are of primary interest to the live-stock farmer. Hence the universal custom of including financial statements, sometimes in minute detail, in reports of feeding experiments, showing how and why the experiment station gained or lost money on each experimental lot, and what such profit or loss amounted to per head. Generally these financial matters find their way into the summary and conclusions of the bulletin, sometimes even to the exclusion of the bona fide experimental results themselves. In any case, it is very often found that such financial statements receive the main emphasis in the accompanying discussion.

The emphasis accorded the cost of experimental feeding operations, and the profits or losses realized, seems to be due to the undoubted

demand for such information from practical live-stock men and also to the fact that a practical comparison of the economy of the different feeding operations under trial cannot be made upon any other basis. A discussion of the results of a series of experiments based entirely upon the feed consumption and the gains secured would be barren of interest to readers desiring information on the most economical methods of feeding live stock, unless supplemented by calculations of receipts and expenditures, probable profits and necessary margins, and the like, calculations, which many readers are reluctant to make because they are not always straight-forward arithmetical calculations and often are time-consuming.

The difficulties in meeting the justifiable demand for some consideration of the financial aspects of experimental feeding operations are well stated by Forbes:[1] "It is impossible to make a statement of the financial outcome of such a comparison of feeds, which will be at the same time useful and true. The reason is that market conditions are never the same at two different times, or in two different places. The relative prices of feeds today, in any given market, do not apply in any other market, and in all probability will never again recur."

Attempts are frequently made to overcome in part the unanswerable objections to the unmodified "financial statement" of a feeding experiment, mainly in the direction of computations of the effect of variations in the prices of feeds on the profits or losses per head. A fairly satisfactory result may be secured with rations containing only two feeds, if the additional mass of tabulated figures is not considered to be detrimental; but with rations including three or more feeds, complicated and less serviceable tables result. Everything considered, this method of modifying the financial statement is not to be recommended. The large amount of tabulated data resulting must seem formidable to one not used to the study of figures, and it may require considerable study to discover just how to enter the tables to obtain values corresponding to any particular set of prices. Furthermore the accurate use of such a table must involve ordinarily two or more interpolations, since any prevailing set of feed prices will not in general correspond to the arbitrary prices used in the compilation of the table.

In general no systematic attempt is made to determine the effect of variations in the cost of feeders and in the margin of selling price over cost, on the profits or losses to be expected in steer and sheep feeding operations. And yet fluctuations in the live-stock market have a preponderating effect in determining the success or failure of the live-stock business. The financial result of the simplest steer or sheep feeding operation (and occasionally of swine feeding operations) de-

[1] Forbes, E. B., Specific Effects of Rations on the Development of Swine. Ohio Agr. Exp. Sta. Bul. No. 213. 1909.

pends upon four main factors, no two of which can be considered to be sufficiently correlated to permit of simplification; these factors are: (1) the cost of feeders per hundredweight; (2) the margin of selling price per hundredweight over cost; (3) the cost of a cereal or nitrogenous concentrate; and (4) the cost of a roughage. No tabulated computations can adequately deal with values influenced by four independent variables, and when the number of variables increases as the rations used increase in complexity, any method heretofore tried, as far as the author is aware, fails completely. Swine feeding operations are generally less difficult to deal with in the formulation of flexible financial statements suitable for use under variable market conditions, since ordinarily in computing profits and losses from such undertakings only the cost and selling price of the pork produced is considered. But even here the tabulated values based on a sliding scale of feed prices cannot be used with accuracy unless interpolation is resorted to.

The nature of the problem of giving a proper financial interpretation to experimental feeding data suggests the use of graphical methods, the main advantages of which are four. In the first place, they do away entirely with large masses of tabulated figures, always confusing to one not used to the study of numerical data. Secondly, they may be used for any values of the variables involved without the necessity of interpolation. Again, they afford a sort of bird's-eye view of the situation, a more or less clear visual representation of the effect of variation in the market prices of commodities on the value under consideration. And, finally, it is possible and entirely feasible in most cases, to superimpose charts representing different experimental lots, upon one another, and thus to afford ready means of comparison. The method also possesses the considerable advantage of being economical of space.

In this study an attempt has been made to apply a few graphical methods[1] to the problem under consideration. The methods selected and illustrated in the following pages may be used with accuracy, and in many cases afford a quick and simple method of performing complicated arithmetical calculations. Many of them are undoubtedly simple enough to be used in experiment station bulletins. Possibly some hesitation might be felt in including some of them in the ordinary bullétin for general distribution. It is hoped that all of them, however, will be found to have a distinct field of usefulness, and when not considered well adapted to bulletins will in any case be of service to extension workers, farm ad-

[1]Deming, H. G., A Manual of Chemical Nomography. University Press, Champaign, Ill., 1918. For a more pretentious and exhaustive presentation of nomographic methods see ''Graphical and Mechanical Computation,'' by Joseph Lipka. John Wiley and Sons, New York, 1918.

visers, editors of farm papers and journals, and to all who are frequently called upon to aid the live-stock farmer in choosing well-balanced and economical rations with due regard to the feeds available, the prevailing market prices, and the probable fluctuations in market conditions during the fattening operation. The value of the methods in classroom work will be obvious.

A GENERAL STATEMENT OF THE PROBLEM

The financial aspect of a feeding operation is naturally resolved into the net receipts[1] from the animal when sold and expenditures incurred in the fattening process. Of the latter the feed bill constitutes by far the larger fraction, and in computing profits or losses is generally the only item considered. The less important items of expense, such as labor, interest, veterinary service, loss of stock by disease or accident, depreciation in buildings and other equipment, insurance, etc., are offset in part, if not entirely, by receipts from the animal other than cash, such as manure and, in the case of steer feeding on heavy corn rations, pork produced from the droppings.

A farmer considering whether or not to fatten live stock during a given season, or to sell his grain directly; or, how much stock to fatten and on what rations, has before him the following more or less exact information. He knows fairly closely what feeder animals will cost him in his feed lot; he knows what feeds are most available to him, as well as something of their quality and their current prices, that is, what he can sell his home-grown feed for, and what imported feeds will cost him. The information he must obtain by calculation or by less certain methods is: (1) his feed bill per head; (2) the necessary margin to cover his expenditures; and (3) considering a probable safe margin in view of the present live-stock market and its tendencies, his probable profit per head. The latter, in turn, he may compute as interest on the money invested or otherwise tied up in the venture, or as returns from his home-grown feeds in comparison with their possible selling price, or as some other value.

The financial presentation of the results of experimental feeding operations should be such as to aid the practical farmer in these calculations and approximations, and, in fact, to encourage him in making them. A mere statement of the financial outcome under any given set of conditions not only gives him no aid or encouragement along these lines, but may actually mislead him into inferring that a substantial profit realized by the experiment station, perhaps under unusually favorable market conditions, may be expected under any conditions.

[1] The term "net receipts" is used thruout this paper to mean simply the selling price of the animal minus the original cost.

CHARTS INVOLVING TWO VARIABLE FACTORS

Fig. 1 illustrates a method of presenting one side of the question; namely, the net receipts per head under given conditions of cost of feeders and margins.[1]

The net receipts per head from steer and sheep fattening operations may be conveniently considered as being derived from two sources: viz. (1) the increase in market value of the initial weight of the animal, which depends of course entirely upon the actual initial weight and the margin of selling price per hundredweight over cost; and (2) the cash realized on the gain in weight produced, which depends upon the size of gain and its selling price. This division of the net receipts may be stated mathematically as follows:

$$r = wm + g\ (c+m), \text{ or}$$
$$r = gc + m\ (w+g),$$

where w is the initial weight of animal; g, the gain per hundredweight; c, the cost of feeders per hundredweight; m, the margin per hundredweight; and r, the net receipts. It is evident, for example, from this equation that for a given margin the net receipts will vary directly with the cost of feeders; or, in other words, for a given margin and feed bill the profits of a feeding operation will increase as the cost of feeders increases, simply because the gains will be marketed at a higher figure.

It will be noted that Fig. 1 presents the results of a venture in baby-beef production in which the calves were raised at home instead of being bought on the market. In computing the net receipts of the baby-beef operation, the scale at the left, therefore, instead of representing the cost of feeders, as it would in most feeding operations, represents the price that the calves might have brought if disposed of directly instead of being fattened. The scale on the right represents the margin of the selling price per hundredweight of baby beef produced over the possible selling price of the unfattened calves. The intermediate scale, derived from the data given at the head of the chart, represents the net receipts realized per head; or, from another point of view, the maximum cost of the feeding operations consistent with no loss or profit. Points on the intermediate scale correspond to any two points on the side scales situated on the same straight line.

The chart is used by placing a ruler, stretched string, or other straight-edge, across it connecting any value for cost of feeders, on the left scale, with the size of margin, on the right, and reading off the

[1] The charts explained and discussed in the following pages were constructed two or three years ago, when the prices of feeds and of live stock were at the highest levels; hence the wide range of prices on the scales of all charts and the high prices chosen in illustrating the method. The fact that practically all the charts are still serviceable when the prices of farm products have dropped enormously is a commentary on the great flexibility of the graphical methods used.

point of intersection on the intermediate scale. For example, if the possible selling price of the calves was $12 per hundredweight and the baby beef sold at a $5.00 margin, the net receipts per head, as indicated by the line drawn across the chart connecting these two values on their respective scales, would be something less than $127.50—approximately $127.30. This value also may be considered as the maximum feed bill consistent with no loss or profit. Every dollar the feed bill falls short of this value represents a dollar profit, if incidental expenditures are left out of consideration.

The chart may be used also in computing the necessary margin in a feeding venture. Suppose the feed consumed per head in this fattening operation should be found to cost at prevailing prices $127.30. Then the straight-edge will be set at this value on the intermediate scale and on the point on the left scale corresponding to the possible selling price of the calves, say $12.00. Then the point of intersection on the right scale gives the necessary margin to just cover expenses, in this case $5.00.

AN ILLUSTRATION IN SHEEP FEEDING

Inspection of Fig. 1 shows the possibility of placing several intermediate scales, representing different experimental lots, between the same two principal scales, affording a ready method of comparing lots, and incidentally economizing space. It is also evident that the same alignment-chart principle illustrated here may be applied to the computation of feed bills for rations consisting of two feeds, under a wide range of price conditions. These statements are illustrated by Figs. 2 and 3, which together constitute a complete financial interpretation of the sheep feeding results upon which they are based.

Fig. 2 permits of rapid estimation of the total feed bill per head for each lot, with a wide range of prices for each of the feeds used (corn and alfalfa hay). As in Fig. 1, the principal scales are at the sides; here they represent a serviceable range in price for each feed. There is an intermediate scale for each of the four lots. By laying a straight-edge across the chart in such a way as to intersect the side scales at points corresponding to the prevailing prices of corn and alfalfa hay, the feed bill per head for each lot may be read off the corresponding intermediate scale. The cross line drawn in, intersecting the side scales at $1.80 corn and $32 alfalfa hay, shows that at these prices the feed bill of Lot 1 would be $5.35; of Lot 2, $5.07; of Lot 3, $4.52; and of Lot 4, $4.27; as near as the scales can be read.

Turning now to Fig. 3, the net receipts per head may be similarly calculated for any cost of range lambs and any margin of selling price per hundredweight over cost. With feeders at $12, and a margin of $2.35, the intersecting line drawn thru the chart indicates upon the intermediate scales the net receipts per head for the different lots.

IOWA BULLETIN No. 181. BABY BEEF PRODUCTION

CALCULATION OF NET RECEIPTS PER HEAD OF BABY BEEVES

AVERAGE INITIAL WEIGHT OF CALVES, 417 LBS.
GAIN OF 626 LBS. IN 386 DAYS

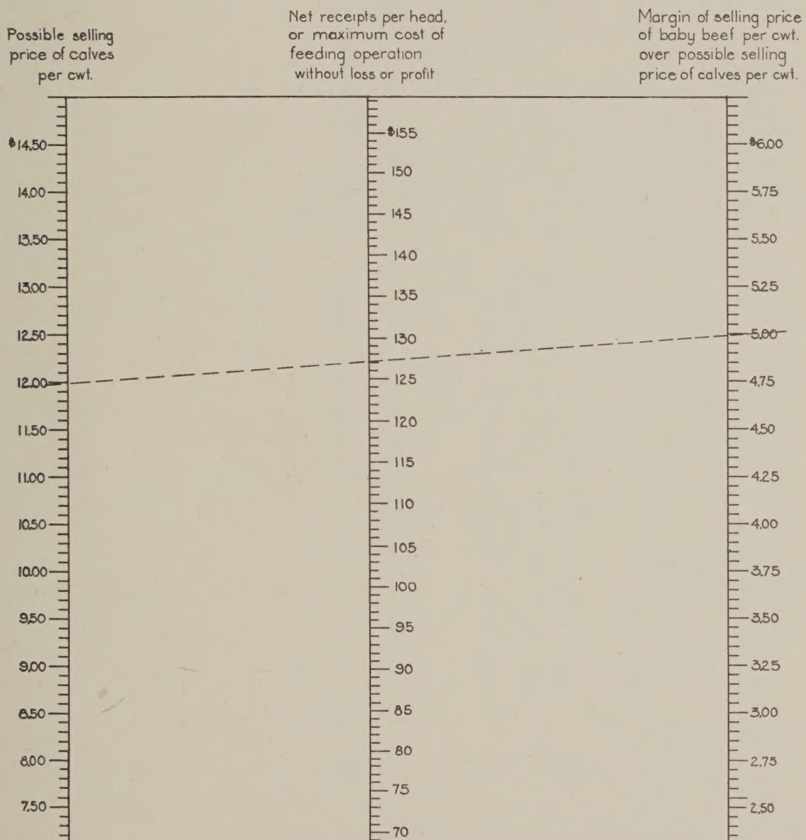

FIG. 1

ILLINOIS BULLETIN No. 167. FATTENING WESTERN LAMBS

CALCULATION OF EXPENDITURE FOR FEED

AVERAGE FEED CONSUMED:

LOT	CORN Bu.	ALFALFA HAY Tons
1	1.993	0.0552
2	1.682	0.0638
3	1.138	0.0771
4	0.871	0.0842

TOTAL FEED BILL PER HEAD.

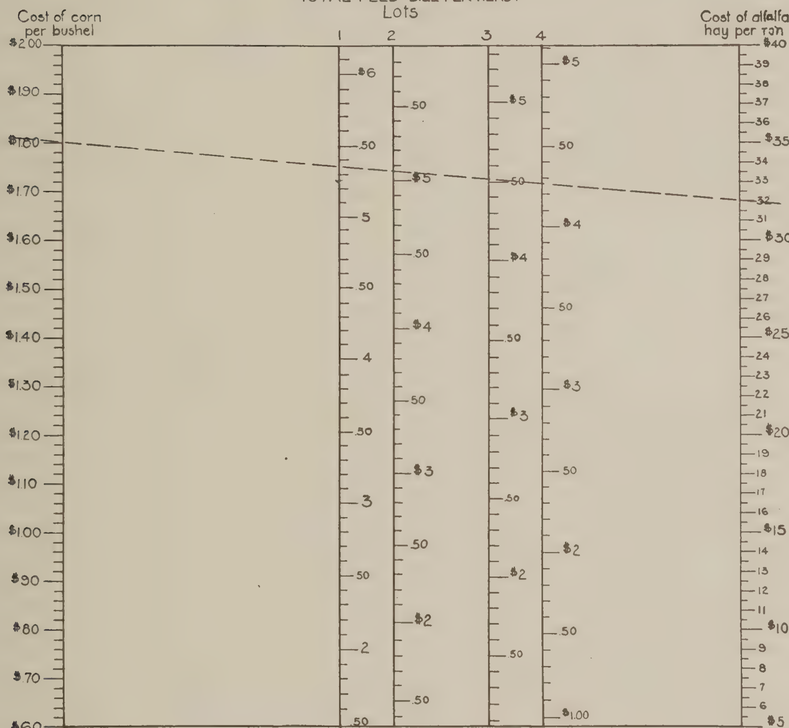

FIG. 2

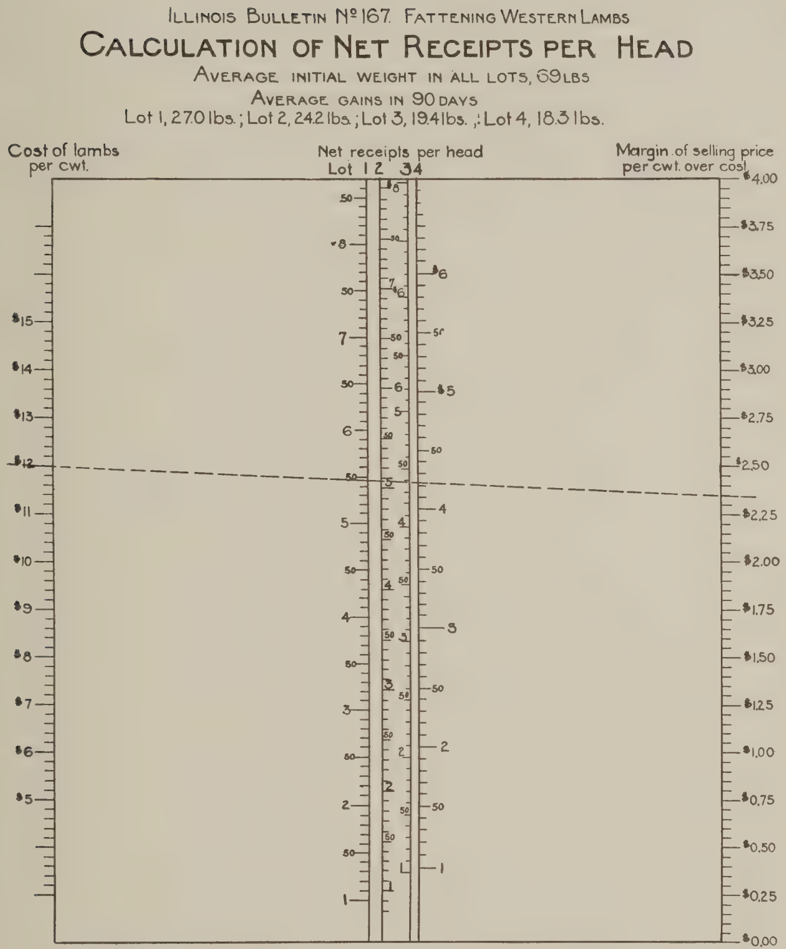
ILLINOIS BULLETIN Nº 167. FATTENING WESTERN LAMBS
CALCULATION OF NET RECEIPTS PER HEAD
AVERAGE INITIAL WEIGHT IN ALL LOTS, 69 LBS
AVERAGE GAINS IN 90 DAYS
Lot 1, 27.0 lbs.; Lot 2, 24.2 lbs.; Lot 3, 19.4 lbs.; Lot 4, 18.3 lbs.
Cost of lambs per cwt.
Net receipts per head
Lot 1 2 3 4
Margin of selling price per cwt. over cost
$15
$14
$13
$12
$11
$10
$9
$8
$7
$6
$5
$4.00
$3.75
$3.50
$3.25
$3.00
$2.75
$2.50
$2.25
$2.00
$1.75
$1.50
$1.25
$1.00
$0.75
$0.50
$0.25
$0.00

FIG. 3

Profits per lot for these four values of corn, alfalfa hay, feeders, and margin, may be readily calculated by subtraction, as follows:

	Lot 1	*Lot 2*	*Lot 3*	*Lot 4*
Net receipts per head (Fig. 3).............	$5.47	$5.08	$4.38	$4.23
Feed bill per head (Fig. 2)................	5.35	5.07	4.52	4.27
Profit per head, by difference...........	+$0.12	+$0.01	—$0.14	—$0.04

Evidently the particular margin chosen for illustration is very near to the necessary margin for each lot.

If the necessary margin is desired for given values of feed and cost of feeders, the procedure is as follows, for, let us say, $1.50 corn, $25 alfalfa hay, and $11.50 feeders. Using Fig. 2, we see that the feed bill for Lots 1, 2, 3, and 4 for the above prices of feeds is $4.36, $4.10, $3.63, and $3.41, respectively. Taking Fig. 3 and placing the straight-edge at $11.50 on the left scale and at $4.36 on the intermediate scale for Lot 1, we find that the necessary margin for this lot, read off the right-hand scale, is $1.32. Placing the straight-edge still at $11.50 on the left scale and at $4.10 on the intermediate scale for Lot 2, the necessary margin is found to be $1.42. Similarly, the necessary margins for Lots 3 and 4 are $1.60 and $1.50. Evidently, on the basis of the prices used, the system of feeding accorded Lot 1, consisting of a maximum of corn, offers better prospects for profit than any other, with Lots 2, 4, and 3 following in order.

When Lot Gains are Nearly Equal

In experiments in which nearly equal gains are made by different lots the inclusion of intermediate scales for the various lots, as in Fig. 3, presents some difficulties. This is illustrated by Fig. 4, in which are given scales for the calculation of the net receipts per head with steers weighing initially 1,000 pounds and gaining 200, 250, 300, 350, and 400 pounds, respectively. Evidently three or four lots of animals gaining within 50 pounds of each other would be represented by intermediate scales clustered so close as to render their proper graduation and reading difficult. This difficulty may be obviated by making single charts for each lot, or by adopting the expedient illustrated in Fig. 5, of using different scales for the cost of the feeders but the same scale for margins. In this case, the side scales for Lots 1 and 4, whose gains differed by 65 pounds, are identical, while with Lots 2 and 3 different scales of cost of feeders are used. While this modification complicates matters somewhat, the chart is just as serviceable as the others when understood.

Illustrations in Swine Feeding

In swine feeding experiments, in which, very often, the ration consists of only two feeds (corn and a supplement), and in which the

profits in feeding are ordinarily figured entirely on the cost of gains (based only on the feed consumed) and the market price of pork, the alignment-chart principle may be used to decided advantage. Take, for example, a recent publication of the Michigan Agricultural College[1] by Norton, in which different supplements to corn are compared on the basis of average figures of the feed consumed per 100 pounds of gain, from a large number of feeding trials from different agricultural experiment stations. The average data thus obtained by Norton are given at the top of Fig. 6. The practical application of these data must evidently involve variations in the market price of corn and the different supplements. The practical question to be answered is, What will pork cost in dollars and cents when swine are fed according to the rations specified? The question is completely answered by the accompanying chart. At the extreme left is the scale of prices of corn per bushel, at the extreme right the scale of prices of supplements per ton, or, in the case of skim milk, per hundredweight. The intermediate scales give the cost of gain per 100 pounds when the swine are fed according to the ration indicated at the upper end of the scale. The cost of gains for corn alone are given on the right side of the line serving as the corn price scale.

As an illustration of the use of the chart, consider the relative cost of the gains produced by the six methods of feeding, with prices at the following levels:

Corn	$ 1.50	per bushel
Tankage	110.00	per ton
Skim milk	.55	per cwt.
Middlings	55.00	per ton
Oil meal	75.00	per ton
Soybean meal	70.00	per ton

From the left-hand scale it is evident that with corn at $1.50 per bushel the corn-alone method would yield pork costing about $13.04. By placing the edge of a ruler at $1.50 on the left scale, and at $110 on the supplement scale on the extreme right, the point of intersection on the corn-and-tankage scale indicates a cost of $12.48 per hundredweight. Keeping the straight-edge still at $1.50 on the corn scale, and shifting the other end to 55 cents on the skim-milk scale on the right, brings the point of intersection on the corn-and-skim-milk scale at the value $11.47. The other values desired, determined in exactly the same way, are $12.87 for corn and middlings, $12.03 for corn and oil meal, and $10.65 for corn and soybean meal. Evidently a ration of corn and soybean meal furnishes the cheapest gain under these conditions, with corn and skim milk next.

[1] Norton, H. W., Jr., Feeding Value of Skim Milk for Swine. Mich. Agr. Col., Special Bul. 92. December, 1918.

NET RECEIPTS PER HEAD FOR FEEDERS WEIGHING 1000 LBS. AND GAINING 200-400 LBS. IN THE FEED LOT

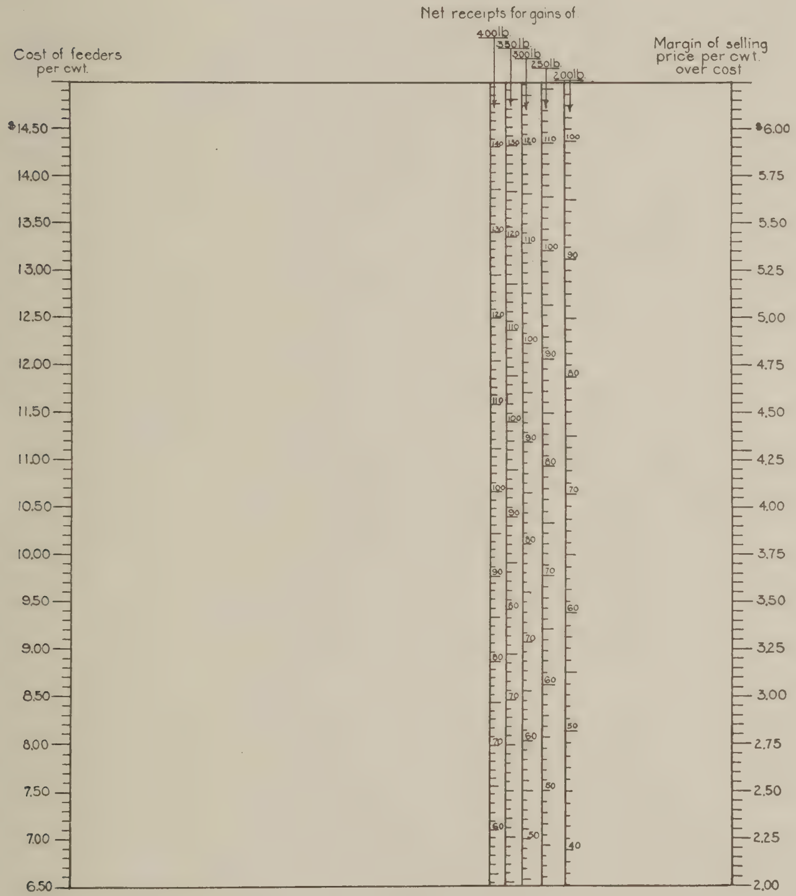

FIG. 4

PURDUE BULLETIN No. 220. STEER FEEDING 1917-1918

CALCULATION OF NET RECEIPTS PER HEAD OF FAT CATTLE

1050 LB. FEEDERS. FEEDING PERIOD 120 DAYS

GAINS:

Lot 1, 212 lbs. Lot 2, 199 lbs.
Lot 3, 224 lbs. Lot 4, 287 lbs.

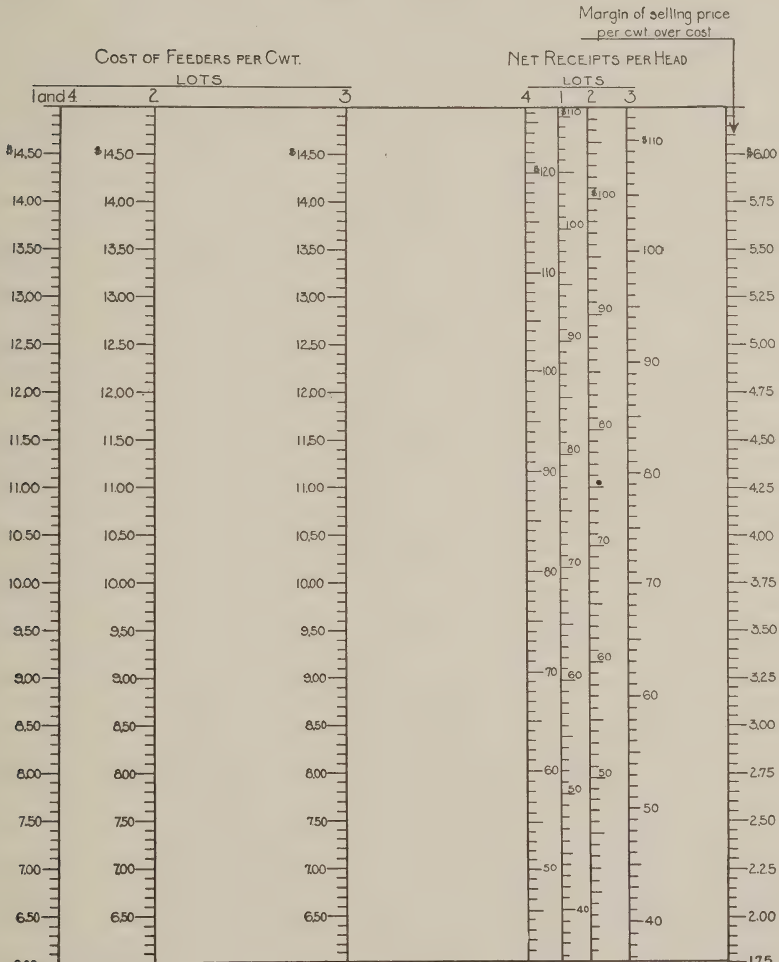

FIG. 5

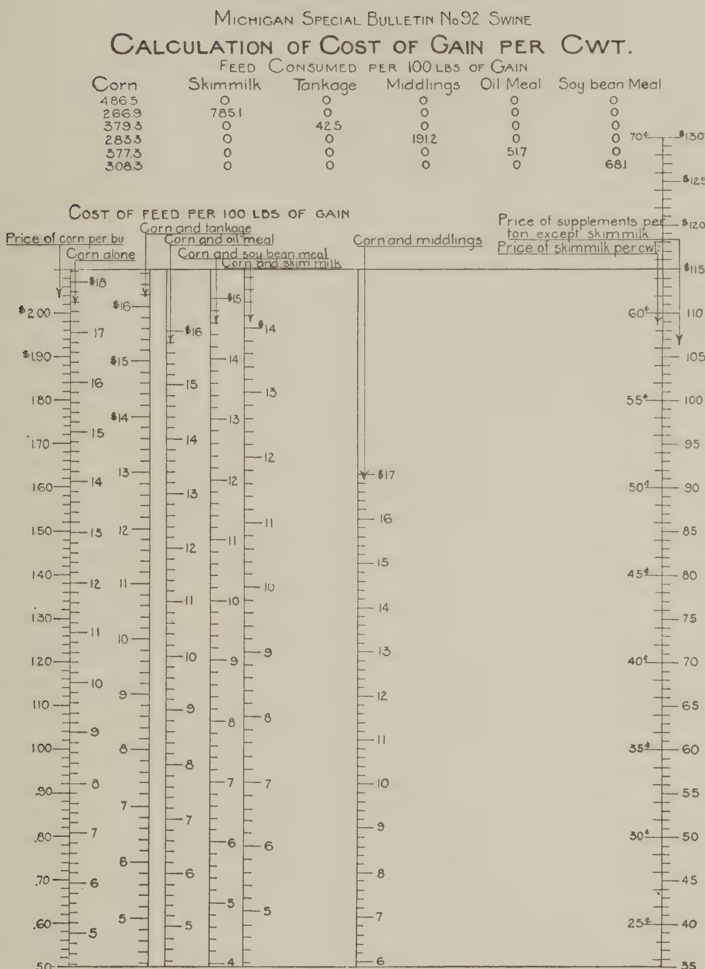
MICHIGAN SPECIAL BULLETIN No.92 SWINE
CALCULATION OF COST OF GAIN PER CWT.
FEED CONSUMED PER 100 LBS OF GAIN
Corn Skimmilk Tankage Middlings Oil Meal Soy bean Meal
486.5 0 0 0 0 0
266.9 785.1 0 0 0 0
379.3 0 42.5 0 0 0
283.3 0 0 191.2 0 0
377.3 0 0 0 51.7 0
308.3 0 0 0 0 68.1
COST OF FEED PER 100 LBS OF GAIN
Price of corn per bu
Corn alone
Corn and tankage
Corn and oil meal
Corn and soy bean meal
Corn and skim milk
Corn and middlings
Price of supplements per ton except skimmilk
Price of skimmilk per cwt.

FIG. 6

The chart is capable of use in another way, such as that suggested by Forbes[1], namely in answering the question, What is the maximum price of supplements at which it would be a matter of indifference whether they be used with corn or not? In other words, with corn valued at any given price, how much can one afford to pay for a supplement and obtain no more expensive gains than if corn were fed alone? The chart gives a direct answer to this question, for any price of corn, thus saving considerable arithmetic. Take, for example, corn at $1.60 per bushel. The scale on the right of the corn price scale shows that at this price a ration of corn alone will produce pork costing practically $13.90 per hundredweight. By placing the ruler at $1.60 on the corn price scale and $13.90 on the corn-and-tankage scale, a line is defined which intersects the price-of-supplement scale far above the highest value given, i. e., at about $145. This means that with corn at $1.60 per bushel tankage can be as high as $145 per ton before it would become unprofitable as a corn supplement. A line drawn thru $1.60 on the corn scale and $13.90 on the corn-and-oil-meal intermediate scale, will intersect the scale at the extreme right at $121, indicating that this supplement may reach this high value before it becomes unprofitable. For soybean meal, the maximum price would be far above the highest price given for supplements; also for skim milk. For middlings, the maximum price is the relatively moderate one of $60.50. In fact, a glance at the chart shows that this supplement compares very poorly, at all prices, with the others. Another illustration of the use of this chart is to find the price that could be paid for a commercial supplement, such as tankage, for given prices of farm feeds, corn, and skim milk. If the latter are priced at $1.40 per bushel and 45 cents per hundredweight, respectively, it may be readily shown by the chart that it would be unprofitable to feed tankage costing more than $32 per ton.

Of course these considerations neglect entirely the rates of gain. The supplements might, as a matter of fact, be profitable to use, at values higher than those found, because of the more rapid gain secured,[2] the saving in labor, and the advantage of an early market.

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[1] Forbes, E. B., Specific Effects of Rations on the Development of Swine. Ohio Agr. Exp. Sta. Bul. 213. 1909.

[2] Obviously the value of a chart such as Fig. 6 is limited only by the value of the experimental data upon which it is based. It is unfortunate, therefore, that the average figures given at the top of the chart were apparently obtained by an indiscriminate averaging of results not necessarily homogeneous, in so far as one may judge from the meager description given of them in the bulletin. The misfortune is that the data cannot be used with any great confidence for pigs of any given weight, such as spring or fall pigs, or for feeding operations resulting in any definite market weight of pigs or for dry-lot or pasture feeding. This is a good illustration of the fact that averages of even large amounts of data, unless the latter are reasonably homogeneous and chosen with discrimination, may be of doubtful value and of little practical utility.

Figs. 7 and 8 are other illustrations of the possibilities in the application of the alignment-chart principle to pig feeding problems. Fig. 7 is a financial interpretation of some results obtained at the Ohio Experiment Station on the feeding of different proportions of skim milk and corn. With corn and skim milk at any given prices, (such as $1.20 per bushel for corn and 45 cents per hundredweight for skim milk), the exact cost of the gains for the different lots may be read off by means of a ruler; namely, Lot 3 (corn 1, skim milk 1), $8.52; Lot 4 (corn 1, skim milk 3), $9.00; Lot 5 (corn 1, skim milk 5), $10.23; Lot 6 (corn and skim milk ad libitum), $10.08. The chart might be more serviceable if the skim-milk scale were extended to 60 or 65 cents, to meet a possible increase in the price of this product.

Fig. 8 is a financial interpretation of the results of another Ohio bulletin on the effect of age on the rate and economy of gains. The data on which the chart is based are given at the head of the chart and represent averages of experiments designated as Nos. 3 and 4, with the exception of the first weight group of 50 to 100 pounds, for which the data of Experiment 3 only were available. The data of this group were obtained from 12 pigs; those for succeeding weight intervals, from 22, 17, 12, and 5 pigs, respectively. To avoid undue congestion of the intermediate scales, the scale of tankage prices for the last weight interval is moved some distance to the left of the corresponding scale of the other weights. The use of the chart is illustrated by the cross line drawn thru $1.80 corn and $110 tankage. At these prices the first 50 pounds of gain was put on at a cost of $10.76 per hundredweight; the next hundred at $11.78; the next at $13.57; the next at $15.38; and the last hundred, shifting the line to the $110 mark on the left tankage scale, was put on at a cost of $16.38.

OHIO BULLETIN No. 316 SUPPLEMENTS TO CORN FOR SWINE IN DRY LOT

CALCULATION OF COST PER 100 LBS. OF GAINS PRODUCED IN SWINE

FIVE PIGS PER LOT AV. INITIAL WEIGHT = 43.7 LBS. FATTENING PERIOD OF 15 WEEKS

LOT	RATIONS— (1) PER DAY—	(2) PER 100 LBS. GAIN—	AVERAGE DAILY GAIN
1.	2.40 LBS. CORN	685 LBS. CORN	0.35 LBS.
2.	3.15 LBS. CORN, 0.35 LBS. TANKAGE	350 LBS. CORN, 39 LBS. TANKAGE	0.90
3.	3.16 LBS. CORN, 3.15 LBS. SK. MILK	330 LBS. CORN, 330 LBS. SK. MILK	0.96
4.	3.41 LBS. CORN, 10.22 LBS. SK. MILK	257 LBS. CORN, 780 LBS. SK. MILK	1.33
5.	3.24 LBS. CORN, 16.18 LBS. SK. MILK	234 LBS. CORN, 1168 LBS. SK. MILK	1.39
6.	3.18 LBS. CORN, 20.53 LBS. SK. MILK	200 LBS. CORN, 1292 LBS. SK. MILK	1.59

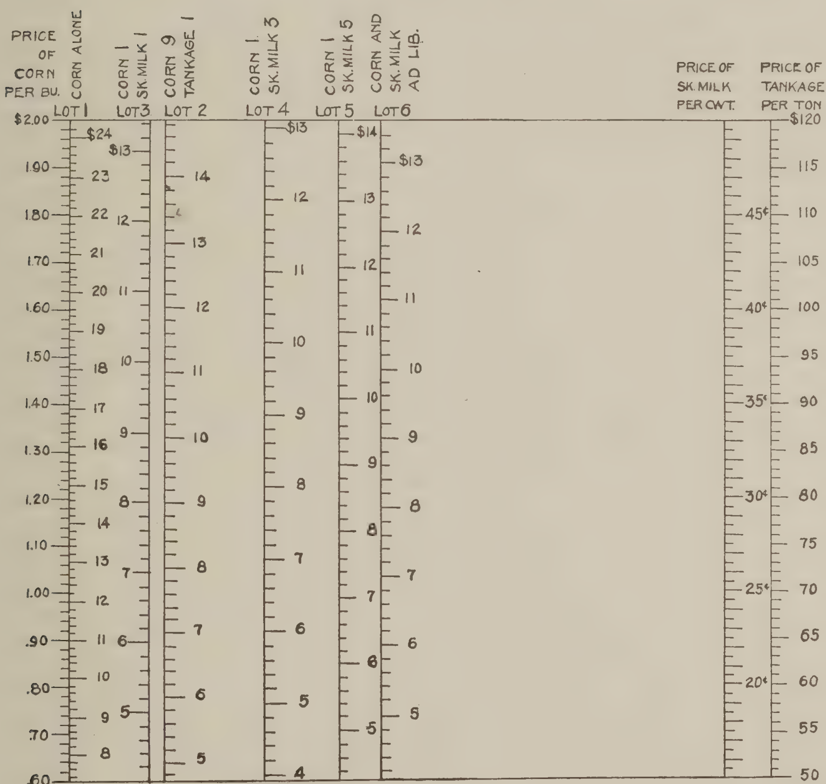


FIG. 7

OHIO BULLETIN NO. 335. EFFECT OF AGE OF PIGS ON THE RATE AND ECONOMY OF GAINS

CALCULATION OF THE COST OF GAINS AT DIFFERENT WEIGHTS

FEED CONSUMED PER 100 LBS. OF GAIN:

1. From	50	to 100 lbs.	282	lbs. corn.	30.7	lbs. tankage
2. "	100	" 200 "	317	" "	28.7	" "
3. "	200	" 300 "	373	" "	28.8	" "
4. "	300	" 400 "	425	" "	30.4	" "
5. "	400	" 500 "	454	" "	32.8	" "

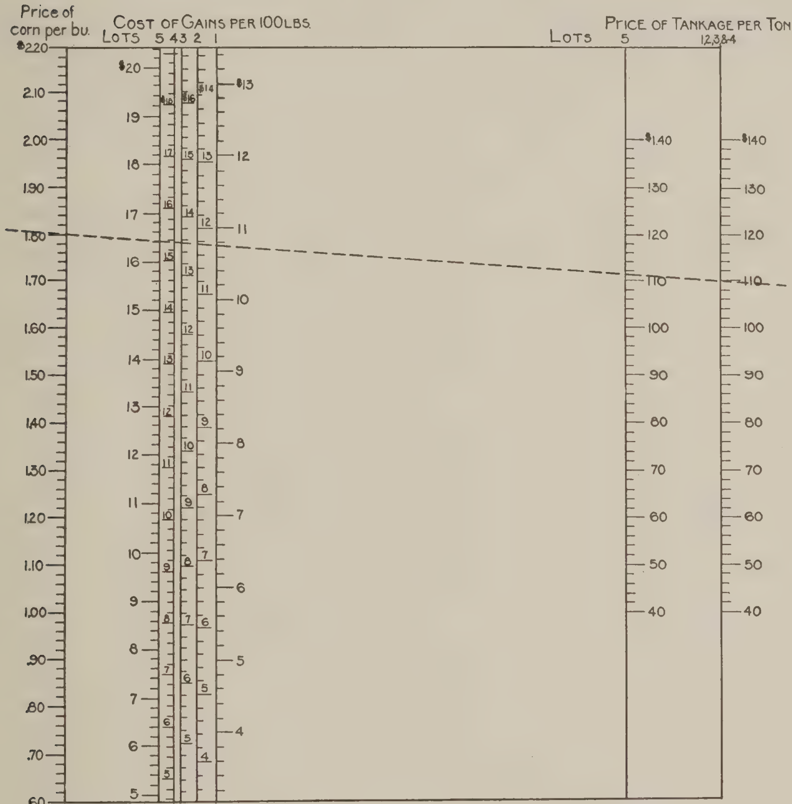


FIG. 8

CHARTS INVOLVING THREE VARIABLE FACTORS

We have thus far considered the financial presentation of results involving only two variable factors: either (1) the cost of feeders and (2) the margin of selling price over cost, in the estimation of the net receipts per head, or of the necessary margin for a given feed bill and cost of feeders; or the prices of two feeds in estimating the feed bill of a ration involving these feeds only. With the presence of three or more variable factors, such as are met in estimating the cost of many of the common rations used in the fattening of steers, sheep, and swine, the graphical interpretation increases somewhat in complexity, tho it is still perfectly straightforward and readily followed on brief study.

AN ILLUSTRATION IN STEER FEEDING

The first illustration of the graphical computation of a feed bill involving three feeds is given in Fig. 9. In the chart on the right, the cost of the feed bill for Lot 2 may be computed. The ration consists of three feeds: clover hay, cottonseed meal, and corn silage. In this case, the price of corn silage is based on the price of corn, a ton of the silage being valued at 6.5 times the price of a bushel of the grain, or 0.182 times the price of a ton of corn. The scale on the left represents the price of clover hay; the scale at the extreme right represents the price of cottonseed meal and corn per ton. The horizontal scale at the bottom facilitates the conversion of corn prices from the bushel to the ton basis. The use of the chart is best illustrated by an example: With corn at $1.60 per bushel, clover hay at $30 per ton, and cottonseed meal at $75 per ton, what will be the feed bill per head for Lot 2? From the horizontal scale it is seen that corn at $1.60 per bushel is valued at about $57.20 per ton, as near as the scale can be read. With a ruler placed at the $30 mark on the clover hay scale, and at the $75 mark on the principal scale at the extreme right, a light line is drawn until it intersects the intermediate ungraduated line as shown. A line is then drawn connecting this point of intersection with the $57.20 mark on the principal scale. Where this line intersects the scale immediately to the left of the principal scale, the cost of the ration ($54.00) is indicated.

The dotted lines on the chart for Lot 1 illustrate the method of computing the cost of ration for this lot, with corn at $1.60 per bushel, clover hay at $30, and cottonseed meal at $73. At these prices, the feed consumed per head would cost $63.30, the corn silage being valued on the basis of the price of corn, as explained above.

In the use of these charts it is not necessary to draw in the lines, but simply to indicate, with pencil, the intersection points on the ungraduated line and on the feed-bill scale.

AN ILLUSTRATION IN SWINE FEEDING

An illustration of the way in which such three-feed charts may be superimposed upon one another is presented by Fig. 10, which gives a financial interpretation of some unpublished swine feeding data from the Illinois Experiment Station. The two side scales, one for tankage and the other for corn, middlings, and oats, are used for both lots. The body of the chart consists of two ungraduated perpendicular lines for the location of intersection points for oats and middlings, respectively, and two other perpendiculars graduated to give the cost of gain per 100 pounds, for each lot. At the bottom of the chart are two conversion scales for corn and oats, equating prices per ton and prices per bushel.

The dotted cross lines indicate the use of the chart when corn is valued at $1.68 per bushel, or $60 per ton (see lower scale); oats 65 cents per bushel, or approximately $40.50 per ton; tankage at $100 per ton; and middlings at $65 per ton. At these prices the cost of 100 pounds of gain would be $15.00 for Lot 14 and $13.05 for Lot 15.

The chart may also be used in answering such a question as this: With corn and tankage at the prices quoted and middlings at $65, how high would oats have to be per ton to raise the cost of pork production in Lot 15 to that of Lot 14; i. e., $15.00? A straight-edge placed on the $60 mark on the right-hand scale and on the $15 mark on the feed-bill scale for Lot 15, would intersect the oats ungraduated line a short distance above the top horizontal line of the chart. Marking this point of intersection after extending the vertical line, and placing the straight-edge at this intersection mark and at the $100 mark on the tankage scale, and we have a line which cuts the right-hand scale at the value sought—in this case, way above the graduations, at almost $90. This means that until oats cost as high as $90 per ton it will be more profitable to fatten hogs according to the ration of Lot 15 than according to the ration of Lot 14 when the prices of corn and tankage are those stated.

PURDUE BULLETIN No. 220 WINTER STEER FEEDING 1917-18

CALCULATION OF TOTAL FEED BILL PER HEAD AT VARYING PRICES

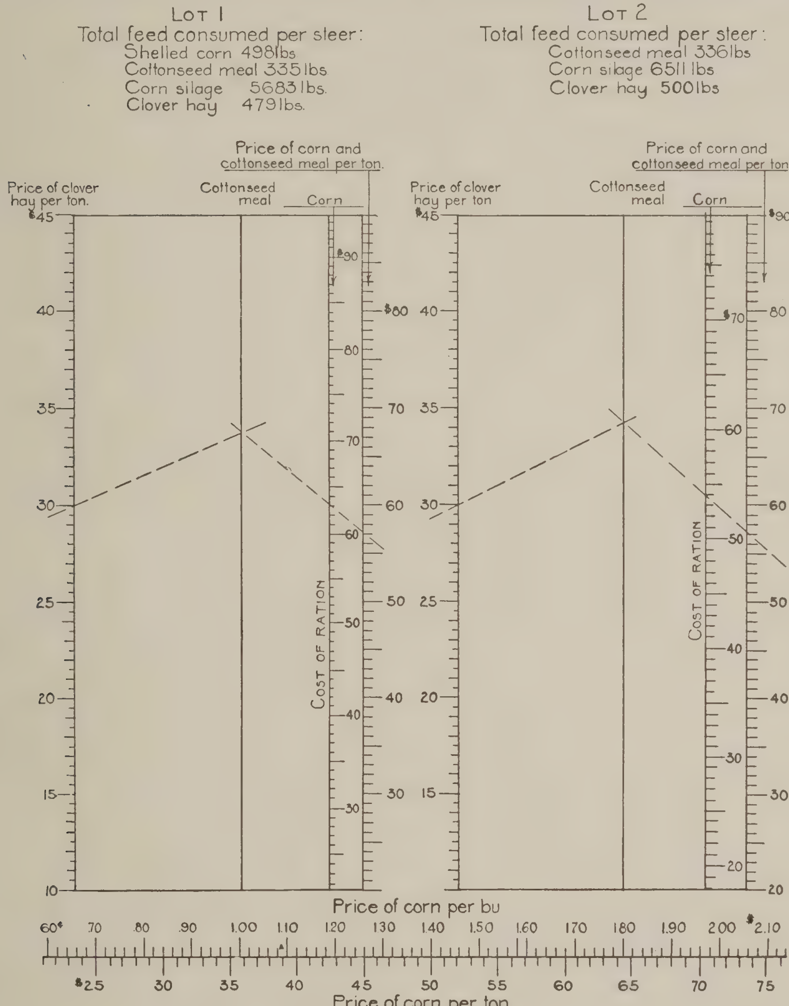


FIG. 9

ILLINOIS RESULTS IN SWINE FEEDING (UNPUBLISHED)

CALCULATION OF FEED BILL PER 100 LBS OF GAIN PRODUCED

LOT 14

291 lbs. of corn, 50 lbs. of tankage, and 117 lbs. of middlings per 100 lbs. of gain } Initial wt. 149 lbs. Av. daily gain 1.13 lbs.

LOT 15

294 lbs. of corn, 52 lbs. of tankage, and 80 lbs. of oats per 100 lbs. gain } Initial wt. 146 lbs. Av. daily gain 1.07 lbs.

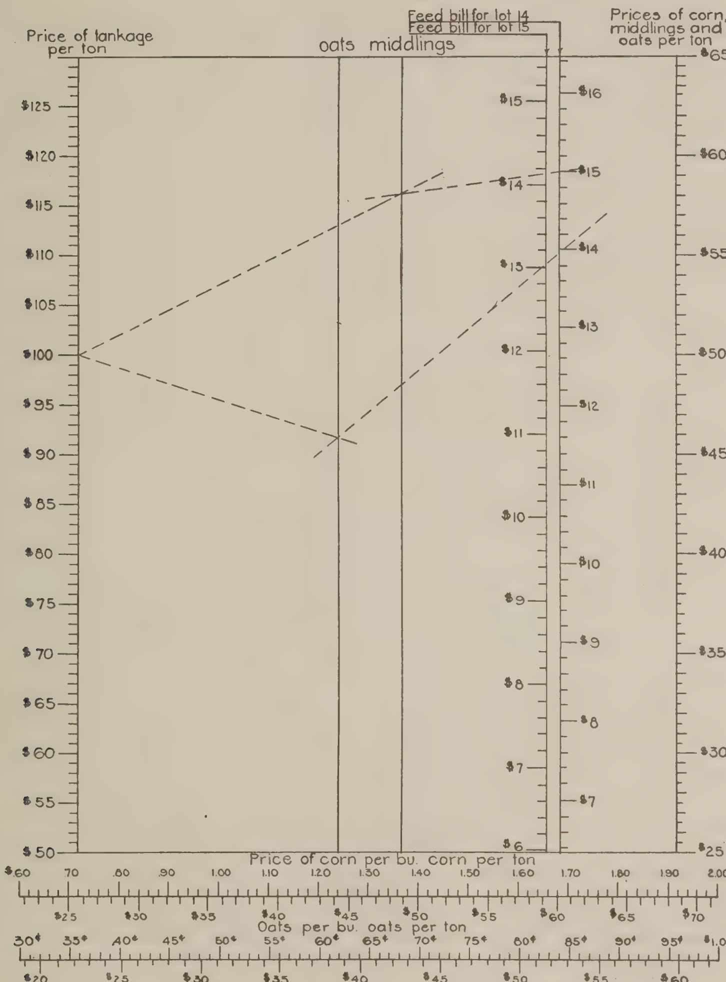


FIG. 10

CHARTS INVOLVING MORE THAN THREE VARIABLE FACTORS

Rations containing three or more feeds, or, more generally, formulas involving the summation of three or more terms, may be solved by a method similar to that shown in the charts just considered.

ILLUSTRATIONS IN MILK PRODUCTION

In Fig. 11 the cost of milk per hundredweight on the herd basis may be computed from a formula proposed by Pearson of the Illinois Experiment Station, involving five items (four feeds and a certain amount of man labor). On the left is the scale for the labor cost per hour. On the right is a line graduated on the outside according to the price of the three types of roughage per ton, and on the inside according to the price of grain per ton. The body of the chart contains three ungraduated lines and one line graduated to indicate the total cost of milk per hundredweight. In determining the intersections on the ungraduated lines in this chart, the items are taken in the order: man labor hours; dry roughage other than hay; hay; grain; and silage. The series of dotted lines traversing the chart indicate the method of computing the cost of milk for the following items of cost:

Man labor	40 cents per hour
Dry roughage other than hay	$10 per ton
Hay	$25 per ton
Grain	$60 per ton
Silage	$10 per ton

The total cost of milk, at these prices, is about $4.04, as is indicated by the intersection point of the last dotted line on the milk-cost scale.

In Fig. 12 the cost of milk may be computed according to a second formula of Pearson's, in which is considered only the expenses involving the individual cow. The total of the items given at the head of the chart, however, account for only 79.58 percent of the total cost. The scale given for the cost of milk per hundredweight is therefore drawn so as to add to the sum of the five specified items 25.6 percent, in order that the total cost may be indicated. The use of this chart is then equivalent to performing five multiplications and additions and one division. The saving of time and mental effort is considerable in this case, and the result finally secured may be read off the scale with errors of only one or two cents at the most. With a larger chart the final result could undoubtedly be read off to the cent. The dotted lines on this chart indicate the method of computing the cost of milk, on the cow basis, with the prices given above. The result obtained is $4.12.

The values obtained by the use of Figs. 11 and 12 represent the average annual cost of milk per hundredweight. The average monthly cost, expressed in terms of its percentage relation to the average yearly cost, according to Pearson,[1] varies from 70.6 percent in June to 120.3 percent in December. Fig. 13 enables one to compute readily this average cost for any month on the basis of any annual average. Thus, on the basis of an average annual cost of $4.03, the average monthly cost for February is obtained by connecting with a straight-edge the February mark on the left-hand scale and the $4.03 mark on the inclined scale, as indicated by the upper dotted line. The monthly average is then read off the right-hand vertical scale at the point of intersection; i. e., $4.62. Similarly, for the month of July the average cost would be $3.38 when the average annual cost is $4.03, as indicated by the second dotted line. A chart of this character thus accomplishes graphically the mathematical processes of multiplication or of division.

Illustrations in Steer Feeding

By means of Fig. 14 a feed bill involving four feeds may be estimated and the necessary margin computed. The broken line traversing the chart from the corn-silage scale to the scale for the feed bill indicates the method of calculating the feed bill for the following prices: silage $9 per ton, alfalfa hay $28, cottonseed meal $75, and corn $1.50 per bushel (or $53.60 per ton; see conversion scale in Fig. 10). The feed bill at these prices is a little over $95 per head, say $95.10. Now if the straight-edge is placed at this point on the feed-bill scale, and at $11.50 on the cost of feeder scale (the outer graduation of the line at the right), the point of intersection on the scale of necessary margin indicates a necessary margin of $3.77.

Fig. 15 gives a similar financial interpretation of the experience of the last ten years at the Purdue Experiment Station with a ration of shelled corn, cottonseed meal, corn silage, and clover hay, for the fattening of feeder steers weighing roughly 900 to 1,100 pounds. In this case, with corn silage at $9, clover hay at $34, cottonseed meal at $75, and corn at $53.60 ($1.50 per bushel), the feed bill for five months is $96. With feeders at $11.50 per hundredweight, the necessary margin in this case is $4.02. The perpendicular scale at the side of the chart takes the calculations a step further, enabling one to compute the profit or loss per steer for any given selling price. Suppose the steers sold for $17.65 per hundredweight. This represents an actual margin of $6.15, exceeding the necessary margin by $2.13. From the side scale,

[1] Pearson, F. A. The Cost of Milk Production Computed on the Year Basis. Ill. Agr. Exp. Sta. Bul. 216. 1919. See page 356.

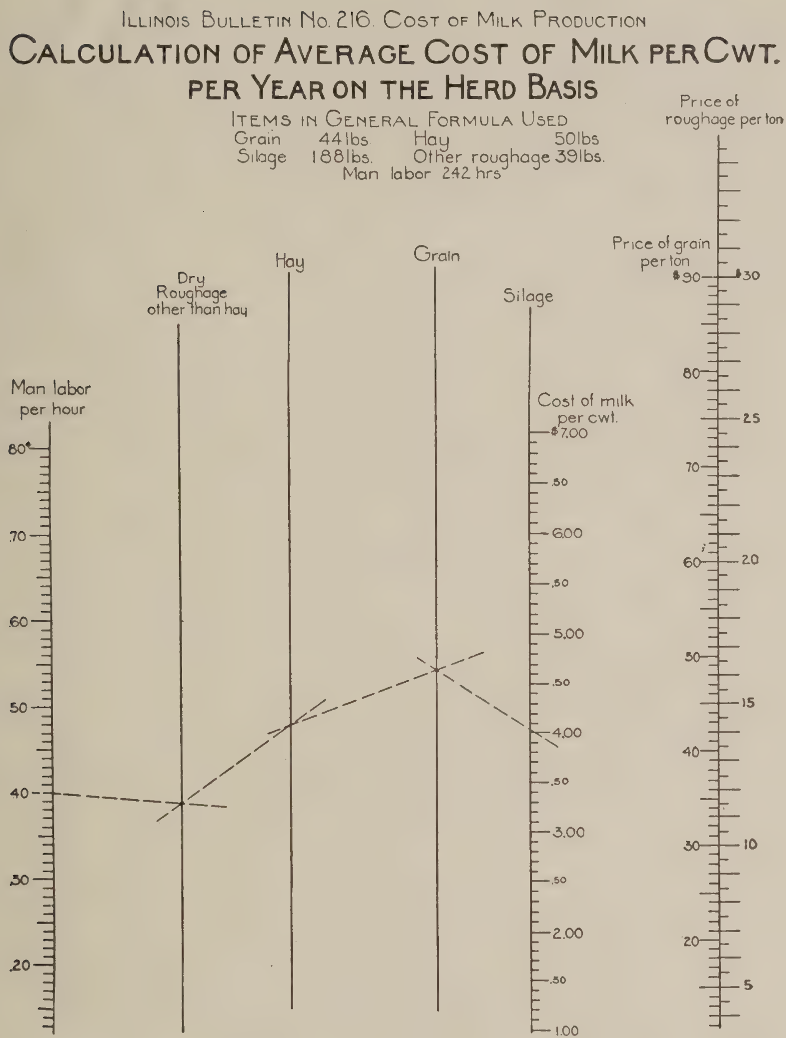

ILLINOIS BULLETIN No. 216. COST OF MILK PRODUCTION
CALCULATION OF AVERAGE COST OF MILK PER CWT. PER YEAR ON THE HERD BASIS
ITEMS IN GENERAL FORMULA USED
Grain 44 lbs. Hay 50 lbs.
Silage 188 lbs. Other roughage 39 lbs.
Man labor 242 hrs.
Price of roughage per ton
Price of grain per ton
Hay
Grain
Dry Roughage other than hay
Silage
Man labor per hour
Cost of milk per cwt.
$7.00
6.00
5.00
4.00
3.00
2.00
1.00
$90
80
70
60
50
40
30
20
$30
25
20
15
10
5
80¢
.70
.60
.50
.40
.30
.20

FIG. 11

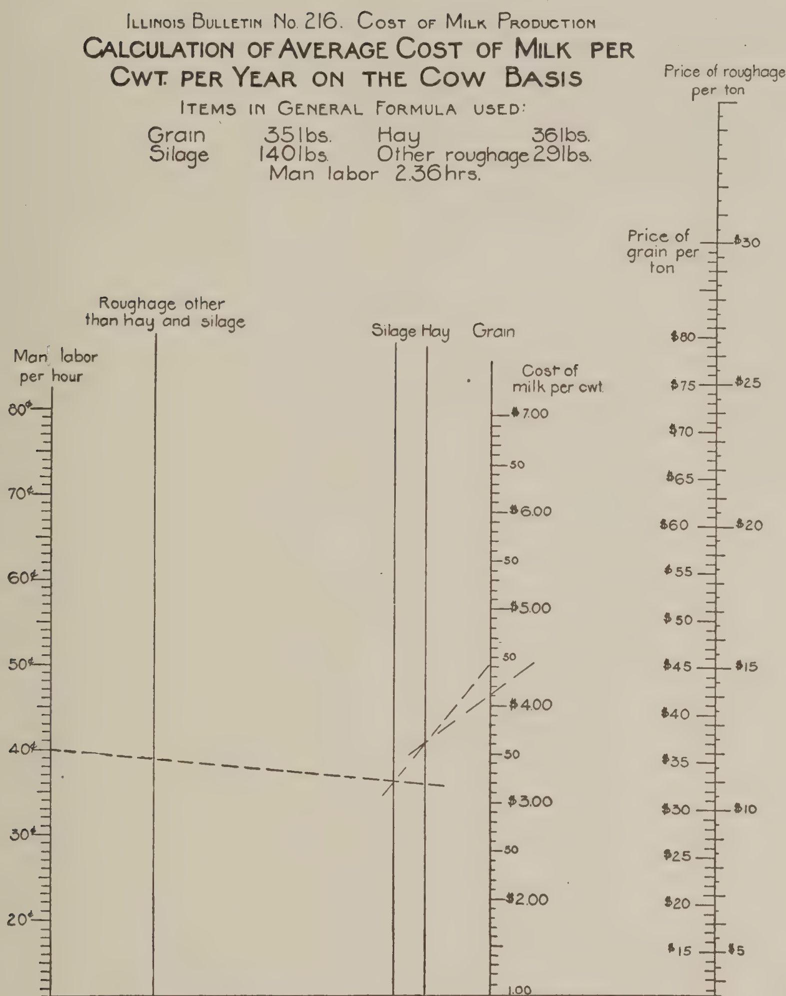

ILLINOIS BULLETIN No. 216. COST OF MILK PRODUCTION
CALCULATION OF AVERAGE COST OF MILK PER CWT. PER YEAR ON THE COW BASIS
ITEMS IN GENERAL FORMULA USED:
Grain 35 lbs. Hay 36 lbs.
Silage 140 lbs. Other roughage 29 lbs.
Man labor 2.36 hrs.
Price of roughage per ton
Price of grain per ton
Roughage other than hay and silage
Silage
Hay
Grain
Man labor per hour
Cost of milk per cwt.
80¢
70¢
60¢
50¢
40¢
30¢
20¢
$7.00
50
$6.00
50
$5.00
50
$4.00
50
$3.00
50
$2.00
1.00
$80
$75
$70
$65
$60
$55
$50
$45
$40
$35
$30
$25
$20
$15
$30
$25
$20
$15
$10
$5

FIG. 12

ILLINOIS BULLETIN NO. 216. COST OF MILK PRODUCTION

CALCULATION OF AVERAGE MONTHLY COST OF MILK PER CWT. FROM AVERAGE YEARLY COST

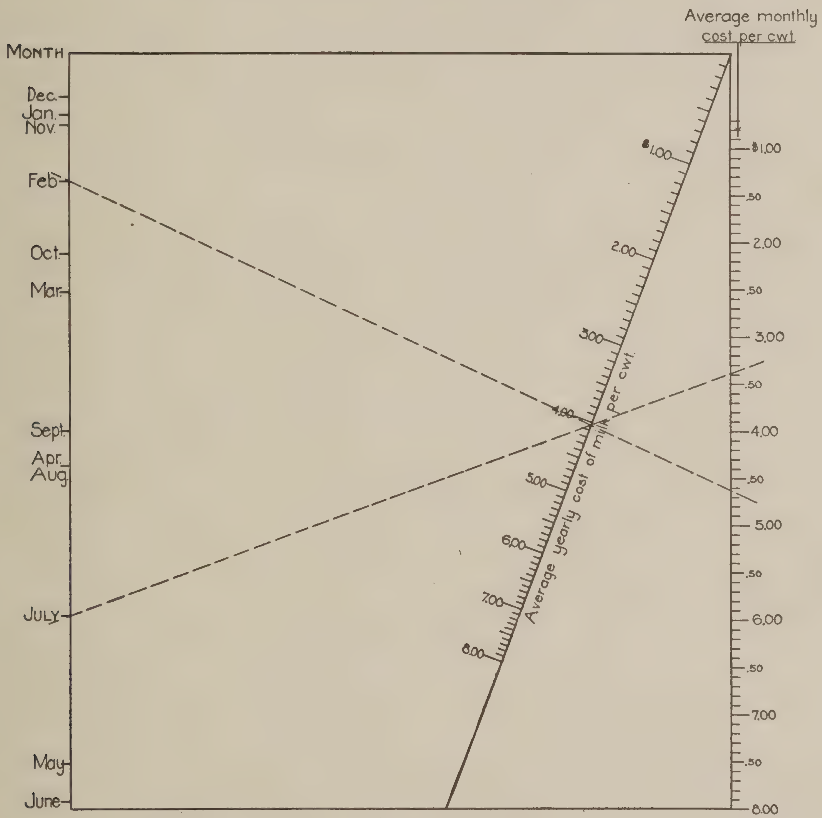
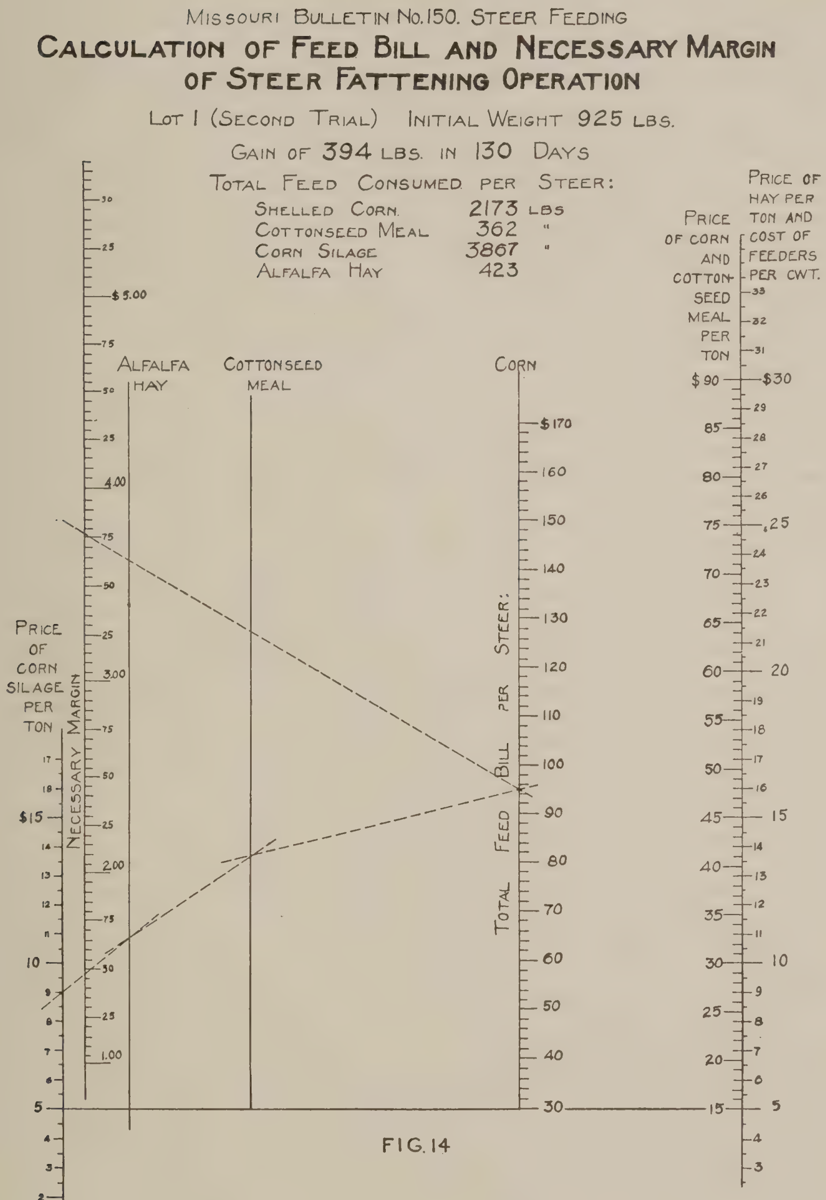


FIG. 13



MISSOURI BULLETIN No. 150. STEER FEEDING
CALCULATION OF FEED BILL AND NECESSARY MARGIN OF STEER FATTENING OPERATION
LOT I (SECOND TRIAL) INITIAL WEIGHT 925 LBS.
GAIN OF 394 LBS. IN 130 DAYS
TOTAL FEED CONSUMED PER STEER:
SHELLED CORN 2173 LBS
COTTONSEED MEAL 362 "
CORN SILAGE 3867 "
ALFALFA HAY 423
PRICE OF CORN AND COTTONSEED MEAL PER TON
PRICE OF HAY PER TON AND COST OF FEEDERS PER CWT.
ALFALFA HAY
COTTONSEED MEAL
CORN
TOTAL FEED BILL PER STEER:
NECESSARY MARGIN
PRICE OF CORN SILAGE PER TON

FIG. 14

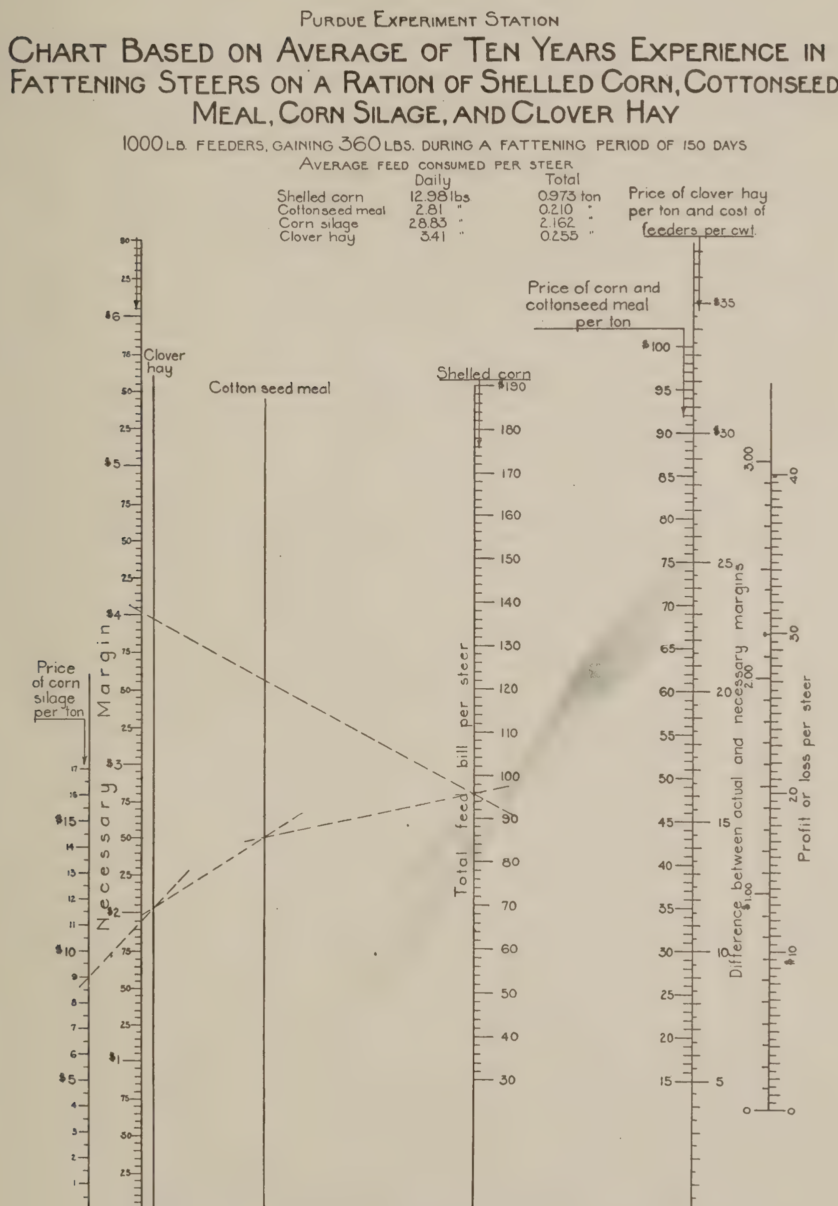

PURDUE EXPERIMENT STATION
CHART BASED ON AVERAGE OF TEN YEARS EXPERIENCE IN FATTENING STEERS ON A RATION OF SHELLED CORN, COTTONSEED MEAL, CORN SILAGE, AND CLOVER HAY
1000 LB. FEEDERS, GAINING 360 LBS. DURING A FATTENING PERIOD OF 150 DAYS
AVERAGE FEED CONSUMED PER STEER
Daily Total
Shelled corn 12.98 lbs. 0.973 ton
Cottonseed meal 2.81 " 0.210 "
Corn silage 28.83 " 2.162 "
Clover hay 3.41 " 0.255 "
Price of clover hay per ton and cost of feeders per cwt.
Price of corn and cottonseed meal per ton
Clover hay
Cotton seed meal
Shelled corn
Price of corn silage per ton
Necessary Margin
Total feed bill per steer
Difference between actual and necessary margins
Profit or loss per steer

FIG. 15

we then find that when the difference between the actual and the necessary margins is $2.13, the profit per steer is $29. Obviously, if the steers sold at the necessary margin, no profit would be realized, while if the selling price had been at a margin of, say $3.75, twenty-seven cents less than the necessary margin, the loss would be, according to the same scale, about $3.70 per head.

CHARTS PERMITTING GREATER FLEXIBILITY IN FINANCIAL PREDICTIONS

The chart just described, constituting a financial interpretation of experimental results at the Purdue Station, is flexible as far as variations in market conditions for live stock and feeds is concerned, but it is nevertheless too rigid to meet *all* conditions confronting the live-stock man desiring to profit by this valuable experimental work. The rigidity impairing the universal usefulness of the chart is due to the fact that no variation is possible in the weight of feeder steers or in the gain secured. It would of course, be impossible for a farmer to secure feeders weighing just 1,000 pounds. In fact, variations of 100 or 200 pounds from this figure would many times be unavoidable. And yet any variation would influence the necessary margin or the estimated profits. This fact, perhaps, is not emphasized fully enough in experiment station bulletins. Feeder steers bought on the market will vary from 850 to 1,150 or 1,200 pounds, and it cannot be assumed that animals of any given average weight can be secured as desired. Again, if feeder animals as secured on the market, varying from 850 to 1,150 pounds, are fed the daily ration prescribed in the manner prescribed, it cannot be expected that at all times gains will be secured at the average rate of 2.4 pounds per head. As a matter of fact, the results at Purdue during the last ten years, obtained from lots of ten animals, have shown gains varying from 2.02 to 2.63 pounds per day, or 303 to 394 pounds in five months of feeding. Of course, a variation in the gains secured may materially affect the necessary margin.

ILLUSTRATIONS IN STEER FEEDING

A chart that permits of flexibility in financial interpretation along the lines mentioned is presented as Fig. 16. The use of the chart is illustrated by the broken transverse lines, involving the same prices and experimental data as Fig. 15; i. e., feeders at $11.50 per 100 pounds, a gain of 360 pounds, a feed bill of $96 per head, and a final weight of 1,360 pounds. A straight-edge placed at the $11.50 mark on the cost-of-feeder scale at the extreme left, and at the 360-pound mark on the inclined scale for gains in weight, is extended to intersect the vertical to the immediate right, and the point of intersection is

indicated in light pencil. This point is then connected by a straight-edge with the $96 mark on the feed-bill scale at the extreme right. The point of intersection on the ungraduated vertical line just to the left of the latter scale is then marked in pencil. The straight-edge is then revolved until it passes thru this point and the 1,360-pound mark on the scale of final weights of steers. This line cuts the intermediate inclined line at the $4.02 mark, thus indicating the necessary margin and duplicating the determination made with Fig. 15. If, however, the feeder steers had been bought at 900 instead of 1,000 pounds, it may be shown from the chart that the necessary margin would have been $4.36; if bought at 800 pounds, it would have been $4.73; or at 1,100 pounds, $3.16; in all cases assuming a gain of 360 pounds. With 1,000 pound feeders and a gain of only 300 pounds, the necessary margin is $4.54; or with a gain of 400 pounds, $3.68. A farmer cannot, of course, make a better prediction of the gains he will secure with a given ration than the experiment station whose directions he is following, but if after two or three months of feeding the ration, his daily gains are much greater or less than those which the experiment station secured, he may modify his prediction, and, with the aid of this chart, his estimated necessary margin.

Fig. 17 permits a further step in financial computations. If with the aid of a feed-bill chart and Fig. 16, a certain necessary margin is computed, the fattening operation is about completed, and the stock man wishes to compute probable profits in view of prevailing prices on the live-stock market, this chart will be of aid. Suppose that with 885-pound feeders costing $10.43 his estimated necessary margin is $4.92 and that the probable gain at the end of the five months of feeding will be 375 pounds. Suppose further that beef such as he expects to produce is selling on the market for $17.50; i. e., at a margin of $7.07. This figure is $2.15 above his necessary margin. Now by using Fig. 17, and connecting the point 1,260 (885+375) on the left scale of final weight of steers, with $2.15 on the inclined scale, his profit, if he secures the above price for his beef, would be indicated by the intersection point on the right vertical scale; namely, as $27.12.

SUGGESTIONS FOR INCREASING THE PRECISION OF FINANCIAL ESTIMATES

In the discussion thus far it has been assumed, as is generally done, that the receipts in feeding operations include only the net returns (as defined on page 274) from the sale of the animals, and that the expenditures include the feed bill only. Some of the incidental expenses are of course allowed for if the cost of feeders is taken to mean the cost in the feed lot and the margin to mean the margin of

Calculation of Necessary Margin of Steer Feeding Operation for Varying Cost of Feeders, Gain Secured, Feed Bill, and Final Weight of Steers

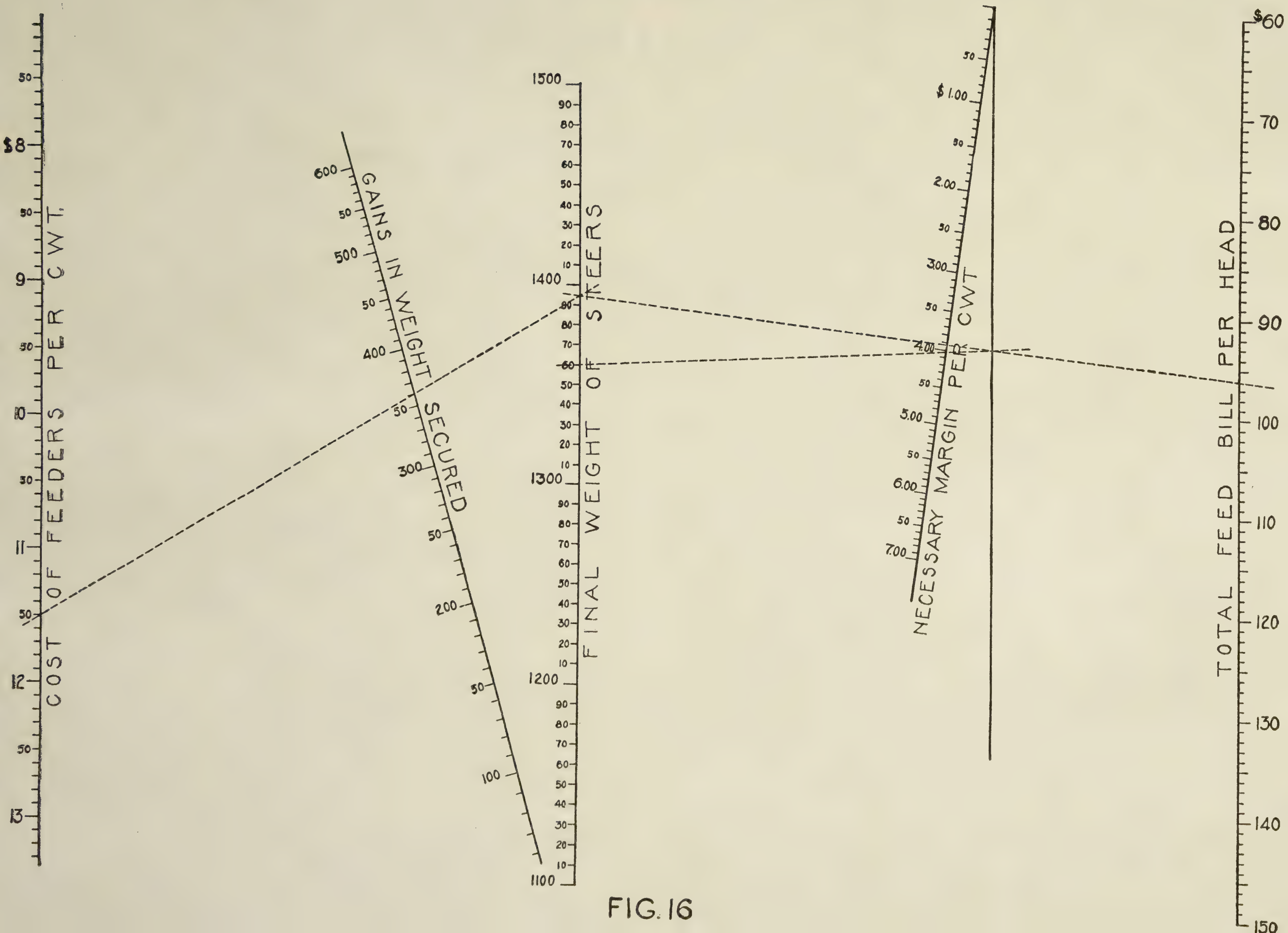


FIG. 16

Calculation of the Profit or Loss per Head in Steer Feeding Operations from:

1. The Final Weight of the Steer, and
2. The Difference between the Actual and Necessary Margins

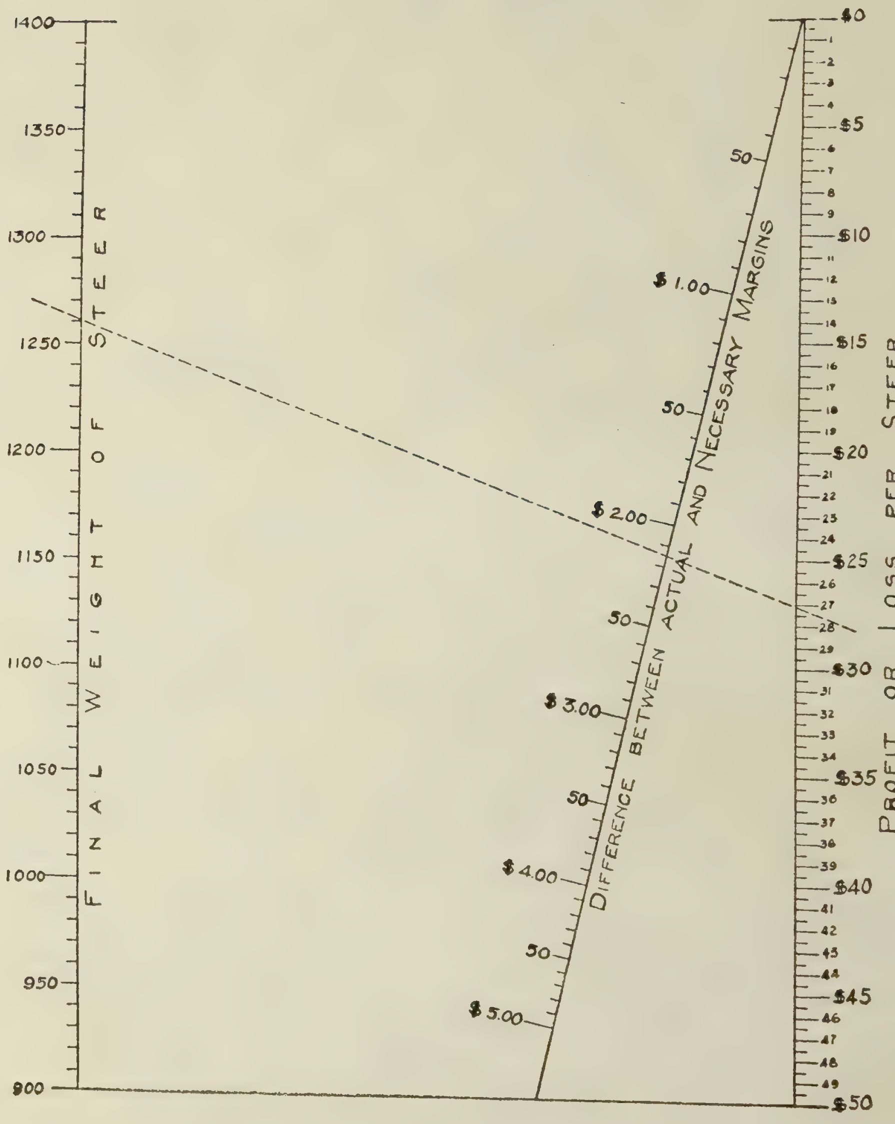


FIG. 17

selling price minus shipping and other incidental expenses, over the cost of the feeders in the feed lot. However, other receipts than the net cash receipts from the sale of animals, such as manure and pork produced from the same, must be recognized, as must also other expenditures than the feed bill, mainly labor, interest, insurance, and taxes. The frequent assumption that the value of manure produced offsets the cost of labor is obviously unsatisfactory. Of greater weight is the conclusion reached in the recent statistical résumé of the meat situation in this country[1] to the effect that in baby beef production the manure and the pork produced almost exactly offset items of expenditure other than feed; but even this conclusion must be discounted in view of the lack of system in the method employed of evaluating the manure, a procedure which was left entirely to the unaided judgment of the live-stock farmer. It would seem advisable in feeding experiments to determine as precisely as practicable the amount of manure produced, its average composition, and its fertilizing value. The collection of the manure should conform only to the best farm practice in collecting manure for distribution as fertilizer on the fields. Only in this way can an accurate estimation of the value of this important item in feeding operations be obtained.

The frequent practice among experiment stations of crediting all pork profits from undigested corn to the steer feeding operation, regardless of the additional corn or supplemental feeds given the hogs, the cost of the latter feeds being deducted from the value of the pork produced, is unsound from every standpoint. Only when check lots of hogs, fed the same way except for the access to steer droppings, are employed, can the actual amount of corn thus utilized, the actual amount of pork produced, and the actual profits realized from this practice be determined (see Iowa Exp. Sta. Bul. 182). When this is done, the results may, perhaps, best be stated as a given amount of pork per bushel of corn in the ration. (Purdue Exp. Sta. Bul. 146, page 605).

Another difficulty in the proper financial interpretation of feeding operations is the evaluation of home-grown feeds of no definite market value. Among these feeds silage is of great importance, figuring largely in steer feeding operations especially. And yet, as far as the author is aware, there is no systematic or commonly recognized method of valuing this feed. Investigation along this line is undoubtedly needed, that it may be ascertained whether there is any close relation between the yield of corn per acre (and possibly its composition) and the amount of corn per ton of silage—to the end that some fair relation may be determined, if possible, between the price of corn and the inherent value of silage. Much of the current discussion as to whether it is profitable to feed corn in rations containing corn silage fed ad libitum,

[1] U. S. Dept. Agr., Report No. 111, Part III, pages 62-63. 1916.

properly supplemented with hay and a nitrogenous concentrate, is of doubtful significance unless a satisfactory method of valuing the silage can be agreed upon, since when the corn is not fed the consumption of silage is enormously increased and becomes an important item in the feed bill.

APPENDIX

Construction of Fig. 1

This type of alignment chart is suitable for the solution of all equations of the form

$$aP + bQ = R, \text{ or } aP - bQ = R,$$

where P, Q, and R are any functions of three variables. The scales for P and Q are the outside scales, while the scale for R is situated somewhere between them. The general equation for its location is

$$x = \frac{bpk}{aq + bp},$$

where x is the distance between the scales for P, on the left, and for R; k is the distance between the scales for P and Q; a and b are the constants in the above equation; and p and q are the unit distances (moduli) on the scales for P and Q, respectively.

The side scales are placed at some arbitrary convenient distance apart, and a reasonable range of values laid off on each, choosing a convenient unit distance, or modulus, for the dollar in each case. In choosing these units, consideration should be given the fact that, according to the equation from which the values on the intermediate scale are to be computed, i. e.,

$$gc + (w + g)m = r, \tag{1}$$

the margin, m, dollar for dollar, is a more important determinant of r than is the cost of calves, c. Hence its unit should be larger.

Having constructed the two side scales, the distance between the left scale and the intermediate scale is computed from the relation

$$x = \frac{(w + g)\, c^1 k}{gm^1 + (w + g)\, c^1}, \tag{2}$$

in which x is the distance desired; c^1 is the distance chosen to represent a dollar on the left-hand scale; k is the distance between the two side scales; m^1 is the distance chosen to represent a dollar on the right-hand scale (the modulus); and w and g have the same significance as in the preceding equation. (See Deming's Manual, page 38; also Lipka, Graphical...Computations, pages 44-64.) Having located the position of the intermediate scale, two points fairly wide apart, say those

for \$85 and \$150, are located on it by long-hand calculation of equation (1), using a straight-edge to connect the values taken for selling price of calves and margin. The distance between these two points is then divided into the proper number of equal parts, in this case 65. (See Deming, page 23.)

Construction of Fig. 2

This chart is similar in general to Fig. 1. In the case of Lot 1, for instance, the equation for the feed bill is

x = 1.993 times the price of corn + 0.0552 times the price of alfalfa hay.

The location of the intermediate scale for this lot is given by

$$x = \frac{0.0552\ c^1\ k}{1.993\ a^1 + 0.0552\ c^1},$$

in which x is the distance from the left-hand scale to the scale for Lot 1; c^1, the distance representing one dollar on the left-hand scale; k, the distance between the two side scales; and a^1, the distance representing one dollar on the right-hand scale.

The scales for the other lots are similarly located. Good judgment should be shown in choosing suitable values for c^1 and a^1. A glance at the rations given at the head of the chart shows that a dollar's variation in the price of corn exerts 10 to 75 times as great an effect on the feed bill as a dollar's variation in the price of alfalfa hay. The units chosen should therefore stand in a somewhat similar relation in order to insure a proper centering of the intermediate scales and a consequent greater accuracy in their use.

With the intermediate scales thus located, definite points on each are found by direct calculation and the use of a ruler or string, and the distances between points on any one scale are divided into the proper number of equal parts in determining the dollar unit distance for each scale.

Construction of Figs. 3 and 4

No additional instructions need be given for these charts. The directions and formulas given for Fig. 1 apply here.

Construction of Fig. 5

The construction of this chart is similar to that of Fig. 1. Equation (2) is used in locating the intermediate scales, varying k as required.

Construction of Fig. 6

After setting up the two extreme side scales for the price of corn and the price of supplements, the intermediate scales are located and graduated in the usual way. Points on the "corn-alone" scale are

located as follows: 486.5 pounds of corn are equivalent to 8.69 bushel. The $18 mark is located on the corn price scale by simple division of this figure by 8.69; similarly to $5 mark. The difference between these two points is then divided into 65 equal parts for a 20-cent interval. The location of an intermediate scale is accomplished as follows. The corn-and-oil-meal ration calls for 377.3 pounds of corn and 51.7 pounds of oil meal, or 6.74 bushel of corn and 0.02585 ton of oil meal. The equation to be solved is therefore

$$6.74\ c + 0.02585\ o = r,$$

where c is the price of corn per bushel and o is the price of oil meal per ton. The distance between the corn price scale on the left and the intermediate scale desired is

$$x = \frac{0.02585\ c^1\ k}{6.74\ o^1 + 0.02585\ c^1},$$

where c^1 is the distance taken to represent one dollar on the corn price scale; o^1, the equivalent distance on the supplement scale; and k, the distance between the two extreme scales. Points on the intermediate line thus located are best found by connecting points on the two outer scales corresponding to even dollar values for r, according to the above equation.

Construction of Figs. 7 and 8

No additional instructions need be given for these charts. The directions given for Fig. 6 apply here.

Construction of Fig. 9

Just as the graphical solution of an equation of the first degree for one variable in terms of two others may be carried out with a triple-parallel chart, so the graphical solution of a linear equation for one variable in terms of any number of other variables, such as

$$aw + bx + cy + dz + \ldots = r,$$

may be carried out by a chart such as this. In this series of functions, a, b, c, d, etc., are constants, representing, in the present case, the weights of feeds consumed; while w, x, y, z, etc., are variables or functions of variables representing in the present case the prices of feeds. A chart for the summation of such terms is constructed by setting up at the extreme right a scale for the variables, and at intervals perpendicular lines, the distance of each of which from the left scale is proportional to the reciprocal of the sum of the constants in the above equations up to and including the term in question. Thus, in the

equation given there would be four uprights, at distances from the left-hand scale proportional to

$$\frac{1}{a}, \quad \frac{1}{a+b}, \quad \frac{1}{a+b+c}, \text{ and } \frac{1}{a+b+c+d}.$$

In the present case the equation of the feed bill of Lot 2, involving 3 feeds, is

$$r = 0.250\,x + 0.168\,y + 3.255\,z,$$

in which x is the price per ton of clover hay, y the price per ton of cottonseed meal, and z the price per ton of corn silage. In the construction of feed-bill charts it is often inconvenient, on account of the great disparity in the price of feeds, to use the same scale for all feeds, according to the unmodified plan. For example, roughages are ordinarily much cheaper per ton than cereals and nitrogenous concentrates, and their price scale should therefore have a greater unit distance for the dollar. Technically speaking, the modulus of the roughage scale should be greater than that of the concentrate scale. And this may be accomplished by multiplying or dividing the constant coefficient according as the modulus of the corresponding price scale is decreased or enlarged. In the present instance, taking the standard price scale as that suitable for cottonseed meal, it is advisable to increase the modulus of the price scale for clover hay by twice, so that the corresponding coefficient is divided by two. Furthermore, it was decided to value the corn silage per ton at 6.5 times the price of corn per bushel; that is 1 ton of corn silage equals in price 364 pounds, or 0.182 ton, of corn. The corn price scale is made the same as the cottonseed meal price scale. The above equation is changed, therefore, to

$$r = 0.125\,x + 0.168\,y + [(3.255)\ (.182) = 0.592]\ z^1,$$

where z^1 is the price of corn per ton. The chart for Lot 2 consists of the scale at the right for corn and cottonseed meal, and three perpendicular lines situated at distances from the scale proportional to the reciprocals of 0.125, (0.125 + 0.168 =) 0.293, and (0.293 + 0.592 =) 0.885. It will be noticed that the clover-hay price scale given on the first line at the left of the chart for Lot 2 has a modulus twice that of the right-hand scale and is arranged so that a given distance above the base line represents a price just half that at an equal height on the right-hand scale. The cottonseed-meal upright is not graduated but the corn line is graduated to represent the total feed bill. This scale is readily constructed since its modulus is $\frac{1}{0.885}$ times that of the principal scale on the right. The \$30 mark on the feed-bill scale, for example, is at the same level as the (30 ÷ 0.885 =) \$33.90 mark on principal scale. Two extreme points can be thus located on this scale, and then the distance between these points divided into the proper number of equal parts.

The chart for Lot 1, to the left of the chart just considered, is constructed in a similar way. If the price of corn silage can be based on the price of corn, as is here done, the four feeds of Lot 1 may be charted as three feeds. The equation to be solved is

$$r = 0.240\ x + 0.168\ y + 2.841\ z + 0.249\ z^1,$$

where x, y, z, and z^1 have the same significance as above. Pricing corn silage per ton at 6.5 times the price of corn per bushel, the last two terms can be combined. The clover-hay modulus is increased by twice and the coefficient correspondingly divided by two, so that the modified equation is

$$r = 0.120\ x + 0.168\ y + [(2.841)\ (0.182) = 0.517 + .249 =]\ 0.766\ z^1.$$

In this case the \$30 mark on the feed-bill scale is at the same level as the (30 ÷ 1.054 =) \$28.46 mark on the principal scale, since the sum of the coefficients in the above equation is 1.054.

Charts such as those just described, involving a reciprocal horizontal scale, are described in Deming's Manual, pages 47 to 50, for the first time. Their use in the present instance is described in the text.

The horizontal scale at the bottom of the chart, for the conversion of prices of corn per bushel into prices per ton, is very simple in construction. Since a bushel of corn is equal to $\frac{1}{35.71}$ ton, each point on the lower graduation equals 35.71 times the corresponding point on the upper graduation. The scale is conveniently made by first laying off the upper scale, using any convenient modulus, and then locating two extreme points on the lower scale. Thus, the \$40 mark on the lower scale coincides with the (40 ÷ 35.71 =) \$1.12 mark on the upper. The distance between the two points thus located is divided into a convenient number of parts.

Construction of Fig. 10

No new principles are involved, aside from the superposition of two charts. For Lot 14, the feed-bill equation is

$$0.025\ x + 0.0585\ y + 0.145\ z = r,$$

where x is the price of tankage; y, the price of middlings; and z, the price of corn per ton. The tankage price scale, given on the left, is taken as the standard, and the other scales for middlings and corn are constructed with a modulus twice as large as that of the tankage scale, and in such a way that any given price on the one scale is at the same level above the base line as twice that price on the other scale. Hence the coefficients for corn and middlings must be divided by two, and the equation reduces to

$$r = 0.025\ x + 0.0292\ y + 0.0725\ z.$$

The distances from the tankage scale to the principal scale on the right, from the middlings ungraduated perpendicular to the same scale, and from the perpendicular bearing the feed bill for Lot 14 per 100 pounds of pork, to the right-hand scale, stand to each other in the proportion of the reciprocals of 0.025, (0.025 + 0.0292 =) 0.0542, and (0.0542 + 0.0725 =) 0.1267. The feed-bill scale for Lot 14 is such that any price on it, say a, is at the same level above the base line as $a \div 0.1267$ on the tankage price scale.

Lot 15 is charted in an exactly similar manner, the same side scales being used for the price of feeds, and the two intermediate lines being located, one ungraduated for oats, and the other so graduated for corn as to give the total feed bill.

The corn conversion scale at the bottom is constructed as already explained. The oat conversion scale is constructed similarly, tho in this case each point on the lower graduation is (2000 ÷ 32 =) 62.5 times the coincident point on the upper graduation.

Construction of Fig. 11

The equation to be solved in this case is

$$2.42\ v + 0.0195\ w + 0.025\ x + 0.022\ y + 0.094\ z = r,$$

in which the variables are the cost of man labor per hour and the prices per ton of roughage other than hay or silage, hay, grain, and silage, respectively. The standard scale adopted is that for roughage, all three types, this scale being set up on the outside of the line on the extreme right. The modulus for the labor scale is 30 times that of the standard, and the scale will be found at the extreme left of the chart. Each value on this scale is at the same level as 30 times its value on the standard scale. The modulus for the grain scale is taken as one-third of the standard modulus. This scale is laid off on the inner side of the line at the extreme right of the chart. The above equation then reduces to

$$0.0807\ v + 0.0195\ w + 0.025\ x + 0.066\ y + 0.094\ z = r.$$

The five lines to the left of the standard scale are at distances from it proportional to the reciprocals of:

Man labor per hour..................		0.0807
Roughage other than hay and silage....	(0.0807 + 0.0195 =)	0.1002
Hay	(0.1002 + 0.0250 =)	0.1252
Grain	(0.1252 + 0.0660 =)	0.1912
Silage	(0.1912 + 0.0940 =)	0.2852

and each value on the scale representing the cost of milk per hundred-weight is therefore equal to 0.2852 times the value at the same level on the standard scale.

Construction of Fig. 12

In this case the sum of the coefficients, after price adjustments are made in the same manner as in Fig. 11, is 0.2337. However, since the sum of the five items enumerated in this case is only 79.58 percent of the total cost of the milk, this figure is divided by 0.7958, giving 0.2937. Hence any value on the scale representing the cost of milk per hundredweight is at the same level as 0.2937 times that on the standard scale. To be more specific, the \$4.00 point on the former scale is at the same level as the (\$4.00 ÷ 0.2937 =) \$13.62 point on the standard scale at the right.

Construction of Fig. 13

This is a transversal alignment chart suitable for multiplying or dividing. In this case, multiplication is accomplished. The equation to be solved is

$$xy = r,$$

where x is the ratio of the average price of milk for a given month to the average price per year; y is the average annual price of milk; and r is the average monthly price of milk. A uniform percentage scale (x) is laid off at the left from 70.6, the lowest percentage (for June), to 120.3, the highest percentage (for December). Instead of indicating percentages on this scale it is sufficient to indicate the name of the month at its proper position on the scale. At the right a uniform scale is laid off for the monthly cost of milk per hundredweight (r), a range from \$1 to \$8 being ample. The cross-line connects the zero points on both of the side scales. In case the zero point on one or both scales is so far removed as to make mechanical connection inconvenient or impossible, the inclined intermediate scale may be located by geometry (see Deming, page 33). The scale on the inclined line is not uniform, but projective. It may be laid off by locating, by the use of a straight-edge, two extreme points and one intermediate point midway between the other two. The points of intersection of any straight line on the inclined line (y) and on the two parallel lines (x and r) stand to each other in the relation indicated by the above equation. From the three points thus located the scale may be laid off by geometric means (see Deming, page 23). For a further discussion of transversal alignment charts see Deming's "Manual," pages 39 to 43, and Lipka's "Graphical and Mechanical Computation," pages 65 to 87.

Construction of Fig. 14

This chart is concerned, first with the calculation of the feed bill for the ration indicated at the top; and second, on the basis of this result

and the cost of feeders, the calculation of the necessary margin when the initial weight of feeders and the gain are as indicated.

The scales to be used in the determination of the feed bill involve no new principle. The standard price scale is taken as that for alfalfa hay and corn silage. The modulus for the corn and cottonseed-meal scales is one-third that of the standard, so that each value on this scale, laid off on the inside of the line at the extreme right of the chart, coincides with a value one-third as great on the standard scale, laid off on the outer side of the same line. The original feed-bill equation,

$$r = 1.933\ w + 0.2115\ x + 0.181\ y + 1.0865\ z,$$

in which w is the price of corn silage per ton; x, that of alfalfa hay; y, that of cottonseed meal; and z, that of corn; becomes, on making the above scale adjustments,

$$r = 1.933\ w + 0.2115\ x + 0.543\ y + 3.2595\ z.$$

If from the feed bill thus determined is subtracted the product of the gain secured, expressed in hundredweight, and the cost of feeders, and the difference is divided by the final weight of the steers in hundredweight, the quotient is the necessary margin. Now the process of subtraction is performed on a chart of this character by working backwards from right to left, just as summation is accomplished by working from left to right. In this chart the vertical lines for the different feeds are located as usual, their distances from the standard scale being proportional to the reciprocals of the following numbers:

Corn silage	1.933
Alfalfa hay	2.144
Cottonseed meal	2.687
Corn	5.946

and the feed-bill scale on the corn upright, at any level, contains values 5.946 times the corresponding value on the standard scale. The subtraction of the product of gain in hundredweight and the cost of feeders, 3.94 v, the standard scale being used for the cost of the feeders, locates a vertical scale removed from the standard scale by a distance proportional to the reciprocal of $5.946 - 3.94 = 2.006$. Dividing this number by 13.19, the final weight in hundredweight, we get 0.1521. Hence any value on the scale of necessary margin equals 0.1521 times the value on the standard scale at the same level. Thus the $10 mark on the standard scale is at the same level as the $1.52 mark on the necessary-margin scale.

Construction of Fig. 15

The construction of this chart is similar to that of Fig. 14. The lower horizontal scale, from which the profit or loss per steer is read

off for any given difference between actual and necessary margin, depends for its construction on the following fundamental equation:

$$gc + (w + g)\ m = r,$$

in which g is the gain in hundredweight and w the initial weight in hundredweight, these being constant; while of the variables, c is the cost of feeders, m the margin per hundredweight, and r the receipts per head. When r just equals the feed bill, or, more generally, the cost of the feeding operation, m is the necessary margin. For every dollar by which the actual margin at which the steers are sold exceeds this necessary margin, the profit secured is obviously equal to $(w + g)$, or the final weight of the steer expressed in hundredweight. For every dollar by which the actual margin falls short of the necessary margin, a corresponding loss of $(w + g)$ dollars must be borne.

Hence a scale is laid off on the upper side of the horizontal line representing differences in dollars and cents between the actual margin and the necessary margin as determined by the chart. A scale may now be laid off on the lower side of the same line to represent the gain or loss realized by making each value on the latter equal to 13.6 times the coincident value on the former scale. If the difference between the actual and the necessary margins is positive, the value read off the lower scale represents profit; if negative, it represents a loss.

Construction of Fig. 16

The purpose of this chart is to facilitate the calculation of the necessary margin for steer feeding operations, for varying cost of feeders, initial weight of feeders, gain secured, and total feed bill. In the fundamental equation given above, if r, the net receipts per head, equals the feed bill, then m becomes the necssary margin and may be obtained by the following equation:

$$m = \frac{f - gc}{w + g},$$

in which f is the feed bill. The left half of the chart represents a multiplication of gain in hundredweight and cost of feeders (see Fig. 13). Since this result in itself has no particular significance it need not be indicated by a scale, which would naturally be placed on the same line as the scale for the final weight of steers. The right half of the chart involves two mathematical operations, a subtraction and a division. The product secured by the multiplication of gain by cost of feeders is subtracted from the feed bill scaled on the line at the extreme right. The difference thus secured is indicated by the intersection on the vertical line situated between the feed-bill scale and the scale of the final weight of steers. Since this difference per se possesses no significance, this vertical line is not graduated. It might

be said here that in triple-parallel charts, such as this, when the two functions involved are scaled on the outside parallels in opposite directions, one scale increasing in value from the bottom upwards and the other from the top downwards, subtraction of the two functions is indicated by the point of intersection on the intermediate line (see Lipka, "Graphical Computation," page 45), instead of addition, as when the outer scales are graduated in the same direction. The difference obtained by the point of intersection on the intermediate vertical line is then divided by the final weight of the steer in hundredweight, the scale for which is on the same line as that used to indicate the product of gain and cost of feeders. A straight line from the point representing the difference between feed bill and the product of gain and cost of feeders, to the final weight of steer intersects the intermediate inclined line (for the construction of which see Fig. 13) at the necessary margin required.

Construction of Fig. 17

The construction of this chart involves the same principles as are involved in Fig. 13 (q.v.).